DEVELOPMENT OF A LOGISTICS
SUPPORT FRAMEWORK FOR
DEFENSE MAPPING AGENCY (DMA)
AUTOMATED SYSTEMS

THESIS

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DEVELOPMENT OF A LOGISTICS SUPPORT FRAMEWORK
FOR
DEFENSE MAPPING AGENCY (DMA) AUTOMATED SYSTEMS

THESIS

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Logistics Management

Thomas R. Mann, B.A.

September 1990

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Once again, Thank you all.

Thomas R. Mann

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Abstract

This study provides an exploratory view of logistical support procedures for Defense Mapping Agency (DMA) automated cartographic or photogrammetric systems. Its purpose was to develop an Integrated Logistics Support (ILS) model tailored to the requirements of DMA automated cartographic or photogrammetric systems.

The literature review identified Ostrofsky's Logistics Systems Management Matrix (LSMM) as an acceptable conceptual foundation for the development of a descriptive logistics support model for DMA.

A Delphi survey provided the means for constructing a descriptive model by polling 31 DMA administrative, research and development, support and maintenance, and production experts.

Research findings supported the need for DMA to implement both a structured, ILS approach to automated cartographic or photogrammetric systems planning and an integrated organizational structure permitting the execution of an ILS plan. The study also certified the need to determine and design logistics support requirements early in the system life cycle with attention given to those support factors identified as unique to DMA. Special considerations should be given to maintenance planning as the experts determined this ILS element as absolutely critical to the

effective logistics support of automated cartographic or photogrammetric systems.

DEVELOPMENT OF A LOGISTICS SUPPORT FRAMEWORK
FOR
DEFENSE MAPPING AGENCY (DMA) AUTOMATED SYSTEMS

I. Introduction

Problem Background

> Although the science of cartography has been in evidence for thousands of years, the full extent of its applications and its value as a source of information has never really been fully exploited. (Pearce, 1987:75)

To exploit these potential applications requires the assistance of complex data processing systems. Converting from a manual to an automated production environment mandates parallel changes in organizational structure and processes (Daft and Steers, 1986:297). Inherent to this trend is the need to maintain and support automated cartographic or photogrammetric systems.

Within the Department of Defense (DOD), the agency responsible for implementing automated cartographic or photogrammetric applications is the Defense Mapping Agency (DMA). The Defense Mapping Agency was formed in 1972 from various Army, Navy, and Air Force mapping, charting, and geodetic organizations. Today over 9000 people provide earth data (mapping, charting, and geodetic data) to all the military services in support of various weapons systems requirements (Larson and Pelletiere, 1989:81). Appendix A

lists the various weapons systems, by major service organization, which DMA supports with earth data products.

> The requirements for DMA's products are generated by the unified and specified commands and the military departments. Even though DMA is controlled by the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence, the Director of DMA is responsible to the Chairman of the Joints Chiefs of Staff for operational matters. (Larson and Pelletiere, 1989:12)

Military high-technology weapon systems and flight simulators require precise digital earth data. To respond to these digital-based earth data systems, DMA converted from manual to automated production processes.

> In 1982, Congress endorsed the Office of the Secretary of Defense mandate that the Defense Mapping Agency should initiate a program to develop an all-digital production system capable of meeting the Armed Forces' critical demands for Mapping, Charting, and Geodetic (MC&G) support. (Department of Defense (DOD)/DMA Digital Production System Handbook, 1989:i)

In 1983, DMA initiated the ten year (1983-1993) Exploitation Modernization Program (EMP). The purpose of the $2.6 billion dollar EMP was to provide a digital production capability known as the Digital Production System (DPS) which is being developed in two phases, MARK 85 and MARK 90 (See Appendices B and C). This modernized digital production capability would result in a 75 percent decrease in production pipeline time and a 50 percent reduction in production costs (Larson and Pelletiere, 1989:81).

To achieve these efficiencies, proper logistical support for automated cartographic or photogrammetric systems providing the digital production capability is

essential. Operations and Maintenance (O&M) and logistical support for DPS systems constitute a substantial amount of the EMP. Approximately 25% of the total allocation for the EMP, or $600 million dollars, was budgeted for logistical support activities (DOD/DMA DPS Maintenance Summary, 1989).

To provide proper logistical support procedures, DMA must incorporate a life cycle management approach for its automated cartographic or photogrammetric systems. A life cycle management approach, Integrated Logistics Support (ILS) is the concept used to support a product from the conceptual phase to the retirement phase. ILS concepts are very important in relation to DMA automated cartographic or photogrammetric systems. Characterized as high-technology and fast-obsolescence, DMA systems require execution of logistical support procedures throughout the entire life cycle of a particular system. This research identified principles of management, design or system life cycle processes, and ILS elements needed to implement and maintain DMA's automated cartographic or photogrammetric systems.

Technological changes in automated cartographic and/or photogrammetric production processes require DMA to continually re-evaluate hardware and software requirements for existing and new systems. The DPS provided DMA with the latest automated cartographic and photogrammetric production technology. Figure 1 illustrates the various DPS segments and the complex interaction between the segments of DMA automated production systems.

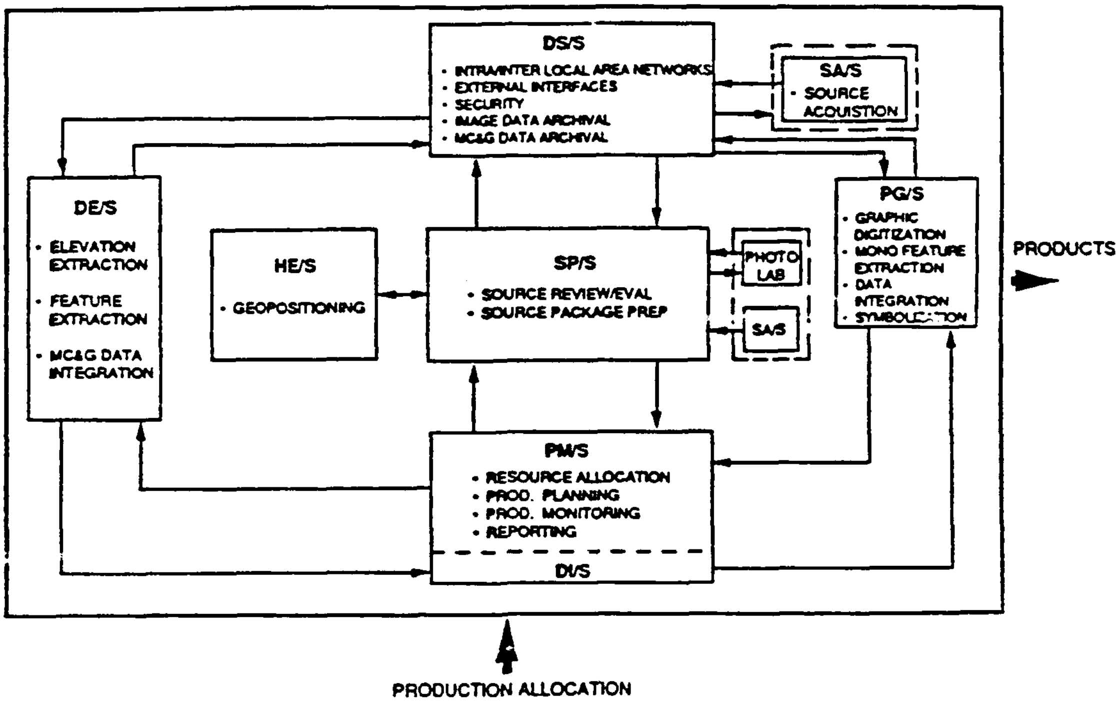


Figure 1. DPS Segments and Functional Flow

Source: (DOD/DMA DPS Handbook, 1989:ii)

The primary functions of the DPS segments illustrated in Figure 1 are to (1) extract terrain elevation and feature data from imagery on a multi-product basis; (2) store that data in a global data base organized by data type and levels within data type; and (3) use that data to generate a variety of graphic and digital earth data products.

The fully operational DPS, shown in Figure 1, contains five MARK 90 segments and two residual MARK 85 segments.

> MARK 85, fully operational in 1987, enhanced hardcopy production methods, improved production and data base management, and provided an initial softcopy production capability. Five years later, MARK 90 segments will replace many MARK 85 segments and provide full digital softcopy production capability and improve production

> management in areas of production programming, scheduling, and resource management. (Department of Defense (DOD)/DMA Digital Production System Handbook, 1989:3)

Proper configuration management controls must be in place to ensure that hardware/software modifications are coordinated with all segments of the DPS system. Configuration controls for maintenance and support are also required for the entire DPS system. Proper logistical support procedures will provide systems operability throughout the DPS and ensure DMA's mission readiness in support of user requirements.

Problem Statement

Although the first phase (MARK 85) of the DPS is fully operational, DMA lacks an integrated approach of formulating logistical support requirements for their automated systems. MARK 90 and future systems such as the Digital Geographic Information Tailoring System (DIGITS) require logistical support planning procedures for on-time implementation (Rivenbark, 1989:8,13).

Research Objectives

This research was initiated to determine how an Integrated Logistics Support (ILS) or other logistical support planning model can provide a framework for determining logistical support requirements for DMA automated cartographic or photogrammetric systems. Specific research objectives addressed were:

1. Develop an ILS or similar logistical support model to address the logistical support requirements for automated cartographic or photogrammetric systems.

2. Validate the model by determining its relevance to DMA automated cartographic or photogrammetric systems.

Research Questions

To fulfill the research objectives, the following investigative questions were addressed:

1. Can DMA experts (administrative, research and development, production, operations support and maintenance) reach a level of consensus on the characteristics and attributes of a logistics support model applicable to automated cartographic or photogrammetric systems?

2. What factors within the ILS elements are unique and applicable to automated cartographic or photogrammetric systems?

3. At what stages of the automated system's life cycle do the ILS elements require determination and design?

Definitions

1. Cartography: The art and science of making maps and charts, globes, and relief models. (Raisz, 1962:293)

2. Earth Data: Quantified and codified information about the earth and the features on its surface. The more common terminology for earth data is mapping, charting, and geodetic data (MC&G). Maps are graphic representations of the land areas of the earth. Charts are used for both nautical and aeronautical navigation. The two types of geodetic data of greatest significance to the military are

the precise locations of points on the earth and gravity measurements. (Larson and Pelletiere, 1989:13)

3. MARK 85: MARK 85 was the first phase of the Digital Production System (DPS) and consisted of six segments. MARK 85 was a transitional step which upgraded DMA's production system and provided initial digital exploitation capability. MARK 85 has been delivered and is in use at DMA production centers. See Appendix B for a more detailed review of MARK 85. (DOD/DMA DPS Handbook, 1989:i)

4. MARK 90: Mark 90 is the second phase of the Digital Production System (DPS) and consists of five MARK 90 segments and the residual of two MARK 85 segments. MARK 90 will provide an all-digital softcopy production system which will improve production efficiencies and accommodate mandatory conversion to exploitation of improved source materials. In March 1991, the MARK 90 system will reach its Initial Operating Capability (IOC). Full Operating Capability (FOC) will occur in March 1992 for all 31 products in the DPS baseline. See Appendix C for a more extensive treatment of MARK 90. (DOD/DMA DPS Handbook, 1989:ii)

5. Logistics: The art and science of management, engineering, and technical activities concerned with requirements, design, and supplying and maintaining resources to support objectives, plans, and operations. (How SOLE Defines Logistics, 1974:18-19)

6. Logistician: An individual whose profession or specialty is performing one of more of the prime management functions (planning, organizing, coordinating, directing, and controlling) in a logistics discipline or functional area or who is responsible for ensuring logistics processes are completed in support of an organization's activities. (Gregor, 1988:8)

7. Integrated Logistics Support: A disciplined, unified, and iterative approach to the management and technical activities necessary to:
(a) integrate support considerations into system and equipment design; (b) develop support requirements that are related consistently to readiness objectives, to design, and to each other; (c) acquire the required support; (d) provide the required support during the operational phase at minimum cost. (DOD Directive 5000.39, 1983:2-2)

Scope and Limitations

Using the Delphi approach, 35 DMA administrative, research and development, production, operations support and maintenance experts were chosen to represent the population of users associated with automated cartographic or photogrammetric systems. The survey population was limited to personnel of the Defense Mapping Agency because of their responsibility in providing graphic and digital cartographic and photogrammetric products for all the military services (Larson and Pelletiere, 1989:12). The descriptive model built was validated and modified based on Delphi results gathered from DMA expert opinions.

The principles of management, depicted in the Logistics Systems Management Matrix (LSMM) portrayed in Chapter II, received limited treatment because the body of management research was far too extensive to review in the course of this research effort. The major focus of the research effort concentrated on the application of design or life cycle phases and Integrated Logistics Support (ILS) elements of the LSMM to automated cartographic or photogrammetric systems.

Conclusion

The Defense Mapping Agency plays an important role in the development and deployment of many major service weapons systems by providing up-to-date and accurate earth data. To meet the requirements of these modern weapons systems, DMA

made dynamic changes in their production processes. Manual techniques were replaced by automated techniques for all possible operations. A $2.6 billion dollar Exploitation Modernization Program (EMP) within DMA was initiated to meet future military requirements. With logistical support constituting 25% or $600 million dollars of the total allocation for the Exploitation Modernization Program, the importance of determining logistical support procedures early in the life cycle of DMA systems is mandatory. Research objectives and research questions were developed to examine the special logistical support needs of automated cartographic or photogrammetric systems.

In Chapter II, a review of the literature presents Ostrofsky's Logistics Systems Management Matrix (LSMM) as a model for determining logistical support requirements for DMA automated cartographic or photogrammetric systems. Chapter III defines the Delphi methodology which provides DMA "experts" the opportunity to furnish data required to develop a logistics support model applicable to automated cartographic or photogrammetric systems. Chapter IV presents the results from two iterations of the Delphi survey. Chapter V summarizes the findings to the research questions and develops a descriptive model to address the logistical support requirements for automated cartographic or photogrammetric systems. Chapter VI presents contributions of this research and recommendations for future research.

II. Literature Review

The identification and application of unique logistics support factors throughout the entire life cycle of DMA automated cartographic or photogrammetric systems is mandatory to ensure the mission readiness of all DOD components. Based on Ostrofsky's Logistics Systems Management Matrix (LSMM), this literature review examined the model's three dimensions and their interrelationships. The LSMM, shown in Figure 2, was used as the foundation for the development of a logistics model applicable to automated cartographic or photogrammetric systems. The concepts derived from this literature review were used to form the Delphi survey questions in Chapter III.

As shown in Figure 2, the LSMM is a three-dimensional model with the principles of management on the "X" axis, design or system life cycle processes on the "Y" axis, and the ILS elements on the "Z" axis. The LSMM forms the basis for proper implementation of a logistics support plan for any given system (Ostrofsky, 1986:8).

Several modifications to Ostrofsky's model were made to implement logistics support procedures for automated cartographic or photogrammetric systems. Staffing was eliminated from Ostrofsky's principles of management axis in the matrix. Most classical management texts reference

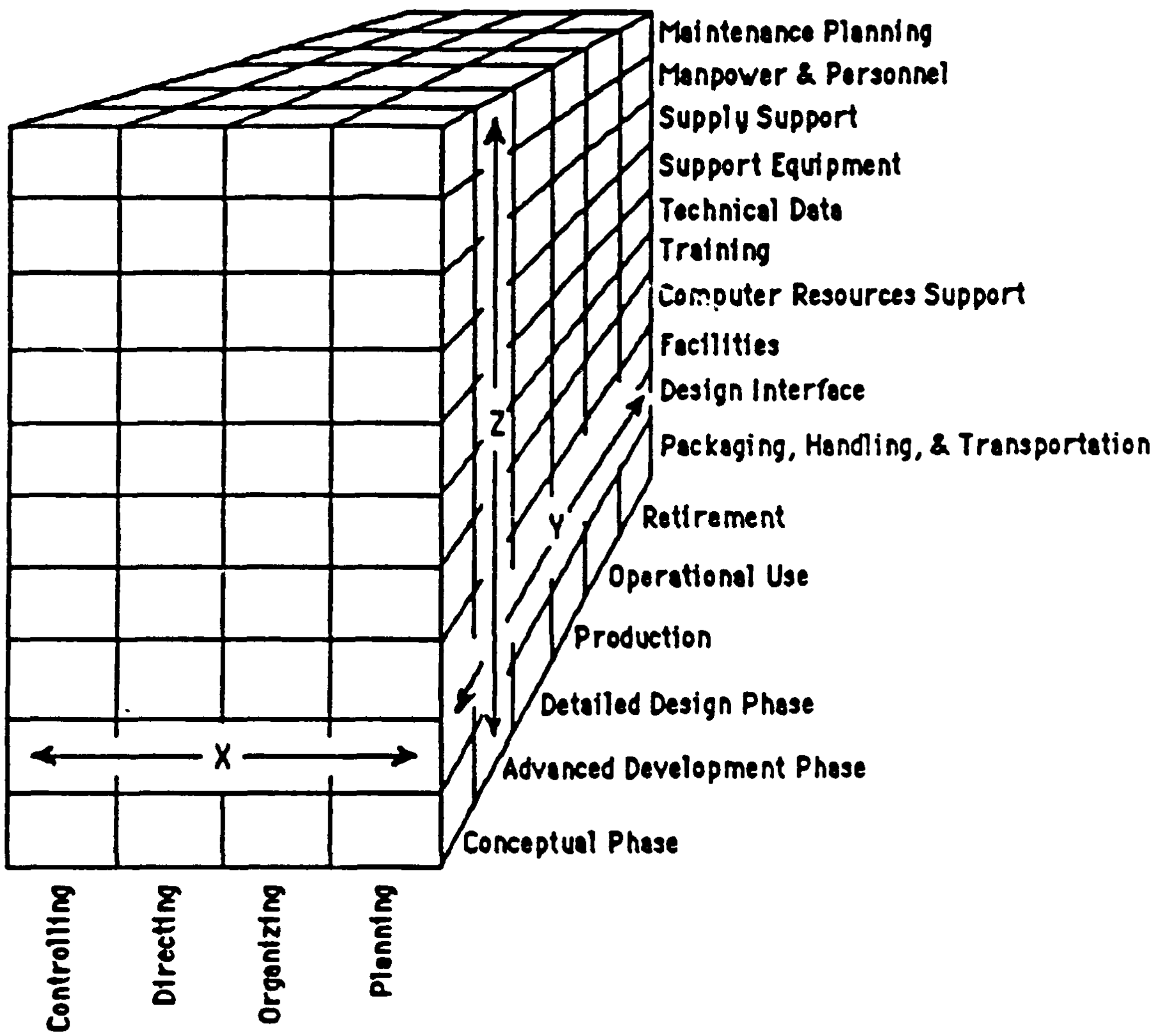


Figure 2. The Logistics Systems Management Matrix

(Ostrofsky, 1986:8)

planning, organizing, controlling, and directing as the principles of management. Daft and Steers stated

> ... management is defined as the process of planning, organizing, directing, and controlling the activities of employees in combination with other organizational resources to accomplish stated organizational objectives. (Daft and Steers, 1986:15)

Substitutions for Ostrofsky's design or system life cycle factors and the ILS elements were made to conform with DOD specifications found in DOD 5000.39. These changes were acceptable as long as the entire system life cycle was shown and the ILS elements were compatible with the particular system application (Ostrofsky, 1986:7).

The literature review identified the LSMM as a suitable framework for determining logistical support requirements for automated cartographic or photogrammetric systems. A limited treatment of the principles of management depicted on the "X" axis of the LSMM was conducted because the body of management research was far too extensive to review in the course of this research effort. Rather, the thrust of the literature review focused on life cycle logistics support applications for automated cartographic or photogrammetric systems. The literature review included (1) the identification of the six basic design or life cycle phases; (2) the identification of the ten ILS elements; and (3) the relationship of the ILS elements as they advance through the design or life cycle phases of a system.

Principles of Management

Planning, organizing, controlling, and directing are the four principles of management studied in most classical management texts. "Fundamental to the management of logistics as with any system, is the comprehension of the principles of management and the nature of the decisions which require resolution" (Ostrofsky, 1986:7).

Planning is the first phase of the management process. Planning involves what is to be done, when to do it, who will do it, and the procedures for accomplishing it (Steiner, 1962:28). Over sixty years ago, Henri Fayol pointed out that managing means looking ahead and that planning is essential in the business environment (Fayol, 1949:43). These ideas are still applicable in present day organizations. Systems planning still must be an integral part of the strategies, policies, and business needs of any organization's logistics operation (Ernst & Whinney, 1987:70).

The field of cartography/photogrammetry is changing at an alarming rate requiring DMA to plan effectively both for the short and long-term. Manual production processes have given way to automated techniques and applications utilizing state-of-the-art computer hardware and software (Larson and Pelletiere, 1989:81). The attributes (i.e. military requirements, high performance graphics hardware, optics, electronics) of these systems continually change due to

advancements in computer technologies (Larson and Pelletiere, 1989:81).

Organizing is the management principle that achieves coordination through a series of tasks and relationships (Matteson and Ivancevich, 1989:83). Organizing can be further broken down in particular organizational types within a particular environment. In high tech environments, there are two primary organizational types. These are

> ... functional organizations which are responsible for administration, policy and procedures, personnel guidance, maintaining technical excellence, and providing skilled personnel... and program organizations which are responsible for directing program activity, developing and maintaining program plans, developing cost and schedule parameters, evaluating progress and status, forecasting, and reporting. (Guthrie, 1984:D.1.4)

Knowledge of the primary organizational components is imperative for DMA logistics managers designing support procedures for automated cartographic or photogrammetric systems. Automated cartographic or photogrammetric systems consist of "highly complex computer oriented systems which include system design, software development, hardware fabrication and assembly and subsequent operations and maintenance on the final product" (Guthrie, 1984:D.1.1). These systems require interaction between organizational components within DMA to accomplish multiple interactive processes. DMA's attempt to facilitate this interaction is illustiated by its organizational structure provided in Appendix D.

Controlling is the management principle that is least understood and is required to "insure that plans and organizations are executed in a manner consistent with achieving the desired results" (Matteson and Ivancevich, 1989:84). The means for establishing criteria and measuring these criteria are mandatory when developing logistics support procedures for automated cartographic or photogrammetric systems. Logistical support data measured throughout the systems' life cycle must be maintained by some configuration control process. The process allows the logistics manager to interact with other components (engineering, production) to control and maintain the integrity of the system throughout the design or life cycle.

Directing is the last of the management principles addressed in this literature review. Synonymous with directing is the work by Fiedler regarding contingency theory. Contingency theory, in leadership terms, "specifies that a group's performance depends upon both leadership style and the nature of the leadership situation" (Daft and Steers, 1986:411). Contingency theory may be applied to logistics management in a similar context. Germain's research states

> ... that management does alter logistical strategy and structure in response to product customization. Managers appear to (1) consolidate fewer logistical activities in a single department (2) rely less on a formalized logistics system and (3) use shorter time periods between updating their strategic logistics plan. In general, these findings are in agreement with contingency theory, or the premise that organizations

are open systems affected by their environment. (Germain, 1989:21)

Recent organizational changes within DMA support Germain's research concerning directing or contingency theory. DMA altered their logistical strategy and structure in response to changing trends in automated production processes. The creation of a new Directorate for Acquisition, Installation, and Logistics provides a direction for identifying and implementing logistical support requirements for automated cartographic or photogrammetric systems.

The application of these four principles of management forms the decision making process that will take place throughout the design or life cycle of automated cartographic or photogrammetric systems at DMA (Ostrofsky, 1986:7).

Design or System Life Cycle

The second dimension of the LSMM "reinforces the establishment of formal areas to be considered in the system life cycle" (Ostrofsky, 1986:8). The specific phases of the system life cycle used in this research differ slightly from Ostrofsky's LSMM although the complete system life cycle is maintained. The design or system life cycle phases selected parallel DOD life cycle phases while providing a less formal approach to be used by DMA experts in the Delphi survey. The six basic design or system life cycle phases to be used are illustrated in Table 1.

Table 1

Design or System Life Cycle Phases

1. Conceptual Phase
2. Advanced Development Phase
3. Detailed Design and Development Phase
4. Production Phase
5. Operational Use Phase
6. Retirement Phase

(Finkelstein and Guertin, 1988:199)

Finkelstein summarizes the six basic design or system life cycle phases as follows

> ... during the conceptual phase a product or system is defined, acquisition requirements are determined, production and operational support requirements are identified and logistics support planning is established. During the advanced development phase the product objectives, performance limits, areas of risk, alterations and acquisition methodologies are determined. Logistics support is performed and the logistics support plan is initiated. During the detailed design and development phase the product is design and tested and the effects on reliability, maintainability, and logistics support are determined. The production phase consists of producing the product and its support and test equipment, spare parts, training, software, and packaging, handling & transportation. The operational use phase includes all activities associated with operational use and logistics support. Retirement consists of all actions necessary to phase out and dispose of a system. (Finkelstein and Guertin, 1988:199)

The function of ILS, as defined in Chapter I, is to maximize system readiness using detailed support elements

throughout the system's life cycle. Logistics Support Analysis (LSA) is an important process to ensure the effective implementation of Integrated Logistics Support (ILS) for any system. LSA is defined as:

> The selective application of scientific and engineering efforts undertaken during the acquisition process, as part of the system engineering and design process, to assist in complying with supportability and other ILS objectives. (Kankey, 1986:4)

LSA allows the logistics manager to examine and define logistics support requirements, estimate logistics support costs, and evaluate logistics alternatives (Comptroller General, 1980:6).

ILS/LSA define many of the logistics support processes that must take place early in the life cycle of a system. To ensure total support throughout the entire life cycle of a system, an aggregate of the ILS elements is necessary (Finkelstein and Guertin, 1988:6).

Retirement is an integral component and function of the system life cycle and must be considered early in the conceptual and advanced development phases (Finkelstein and Guertin, 1988:204). Fast obsolescence systems, such as automated cartographic or photogrammetric systems, require retirement planning early in the life cycle. ILS requirements determination for existing systems and future systems are driven by the ability to predict retirement periods for given systems.

Integrated Logistics Support (ILS) Elements

The ten ILS elements selected for this research come directly from DODD 5000.39 and are illustrated in Table 2.

Table 2

Integrated Logistics Support (ILS) Elements

1. Maintenance Planning
2. Manpower and Personnel
3. Supply Support
4. Support Equipment
5. Technical Data
6. Training
7. Computer Resources Support
8. Facilities
9. Packaging, Handling, Storage & Transportation
10. Design Interface

(DODD 5000.39)

Although automated cartographic or photogrammetric systems are smaller acquisition programs than perhaps a large weapon system employed by the Air Force, the evaluation of their ILS elements remains the same (Materna and Andrews, 1988:5-4). Many times the ILS elements are managed separately, but the integration of the remaining elements must be considered when applying the principles of management to logistics support tasks for automated

cartographic or photogrammetric systems. Another important concept in determining logistics support requirements for automated cartographic or photogrammetric systems is the relationship between the ILS elements and the system life cycle.

ILS Elements/System Life Cycle Relationship

Integration of ILS elements and system life cycle is required for successful implementation of any system. To conduct a systematic literature review, each ILS element will be analyzed as it advances through the phases of the system life cycle. A figure will accompany each ILS element illustrating events which take place during phases of the system life cycle.

Maintenance Planning. This ILS element is the first of ten elements a logistics manager must evaluate. Maintenance planning is "the process to develop the maintenance concepts and maintenance requirements of the system" (ILS Guide, 1986:7-5). Figure 3 illustrates the maintenance planning element as it advances through the system life cycle phases.

The maintenance concept is the first step in the maintenance planning process and is developed during the conceptual phase of the system life cycle. The maintenance concept is a statement of guidelines used in developing the maintenance plan for a system or item of equipment (Jones, 1987:65).

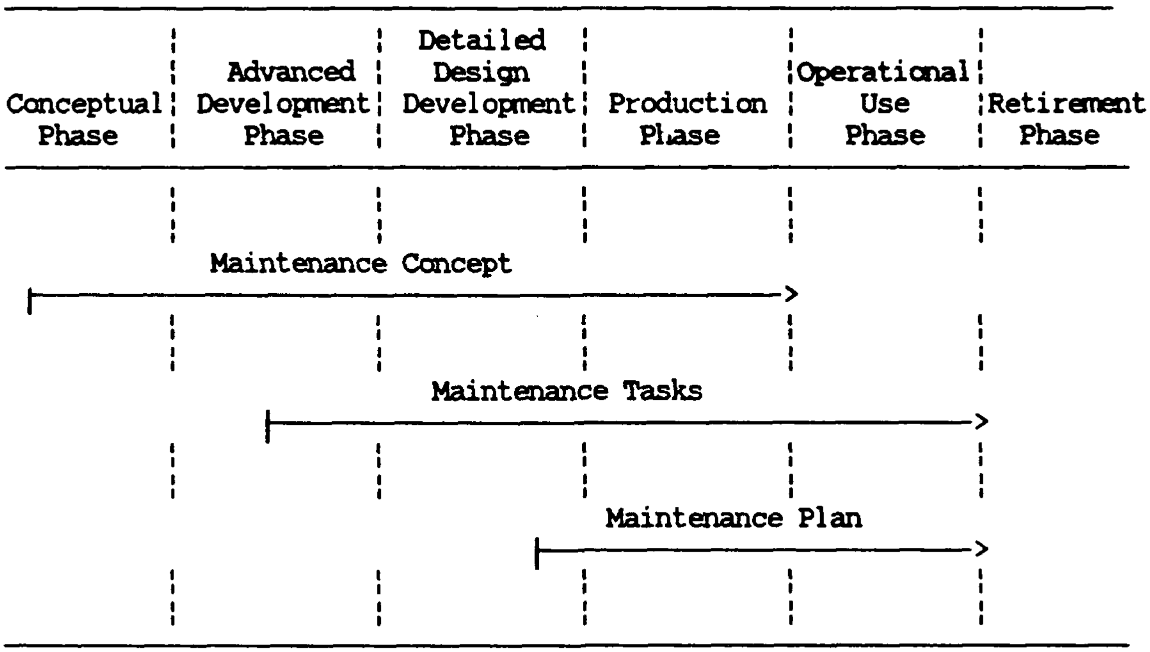


Figure 3. Maintenance Planning/Life Cycle Relationship

Jones states that the guidelines addressed by the maintenance concept include

> ... (1) a strategy for allocating maintenance tasks to the different levels of maintenance; (2) the repair policy regarding similar types of items contained in the equipment; (3) the criteria for scheduling maintenance tasks; and (4) the availability of resources to support maintenance. (Jones, 1987:65)

This concept must agree with the operational requirements and financial constraints of the system (Finkelstein and Guertin, 1988:102). The concept requires a careful examination of the complete structure of the system. The maintenance planning concept is the "lead analytical activity and provides input to the development of all of the remaining ILS elements" (ILS Guide, 1986:7-5).

As the system advances through the life cycle, maintenance planning is updated. The maintenance concept is

compared with the projected resources and constraints that may be present when the system or equipment is fielded (Jones, 1987:65). Specific maintenance tasks are identified in conjunction with operational requirements during the advanced development phase and the detailed design and development phase.

At the end of the detailed design and development phase or early in the production phase a detailed maintenance plan is created (Finkelstein and Guertin, 1988:110). "Maintenance planning identifies the level of maintenance at which each task is performed, the tools and equipment required, and the times and frequencies (ILS Guide, 1986: 7-5). The maintenance planning document created at this stage is updated throughout the life cycle as needed.

Manpower and Personnel. This ILS element requires identifying personnel needed to operate and support the system throughout the life cycle. Figure 4 illustrates the manpower and personnel element as it advances through the system life cycle phases.

Identification of the skills necessary and the manpower constraints are required prior to the initiation of the program (ILS Guide, 1986:7-5). During the conceptual phase the first estimate of needed manpower criteria is performed. These initial estimates can be based on historical data from prior systems that are similar to the system being developed (ILS Guide, 1986:3-4). There are also models which can be

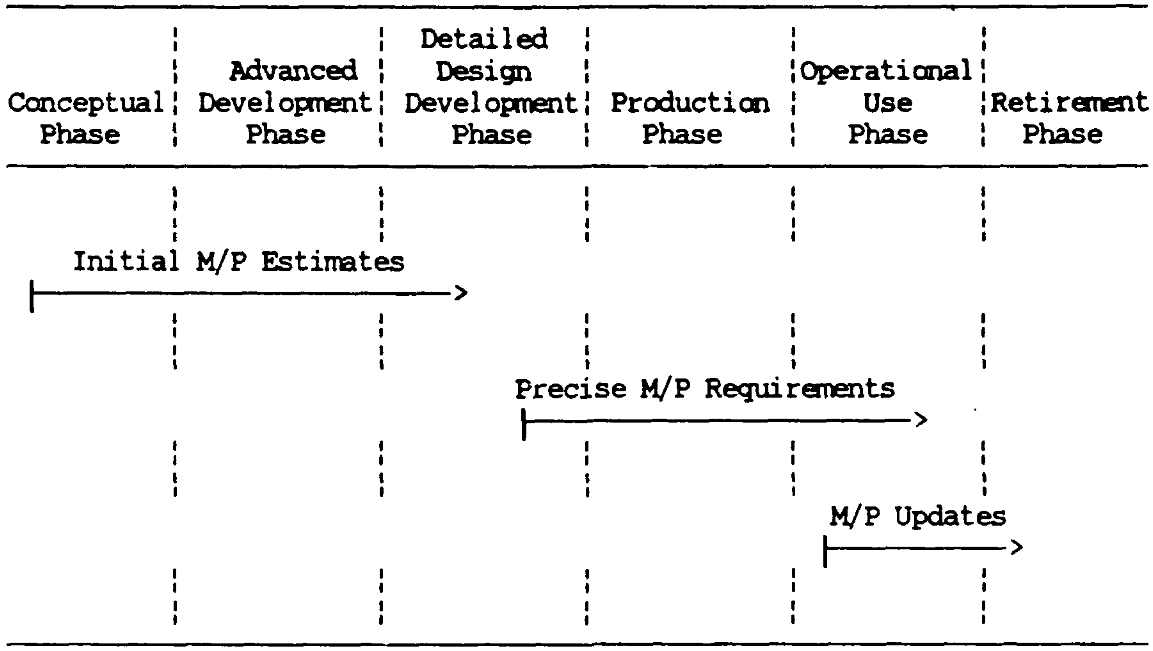


Figure 4. Manpower and Personnel(M/P)/Life Cycle Relationship

procured for estimating manpower and personnel requirements. "HARDMAN, is an analytical tool which predicts quantitative manpower and personnel requirements in different skills" (ILS Guide, 1986:7-5).

To ensure the required support is maintained throughout the system life cycle, the quantity, type, and appropriate skill levels of maintenance personnel must be attained (Finkelstein and Guertin, 1988:114). Late in the detailed design and development phase this information is more attainable and precise manpower and personnel requirements can be formulated. These fine-tuned requirements are the foundation to ensure proper implementation after the production phase and into the operational use phase. Adjustments to manpower and

personnel can be made according to operational data and production requirements throughout the remaining life cycle.

Supply Support. This element encompasses all actions required to identify and obtain the spares and repair parts needed to implement a given system (ILS Guide, 1986:7-8). Figure 5 illustrates the supply support element as it advances through the system life cycle phases.

Supply support is initiated during the advanced development phase of the system life cycle. Due to the rapid technological advancements in the computer environment, parts obsolescence is an important concept

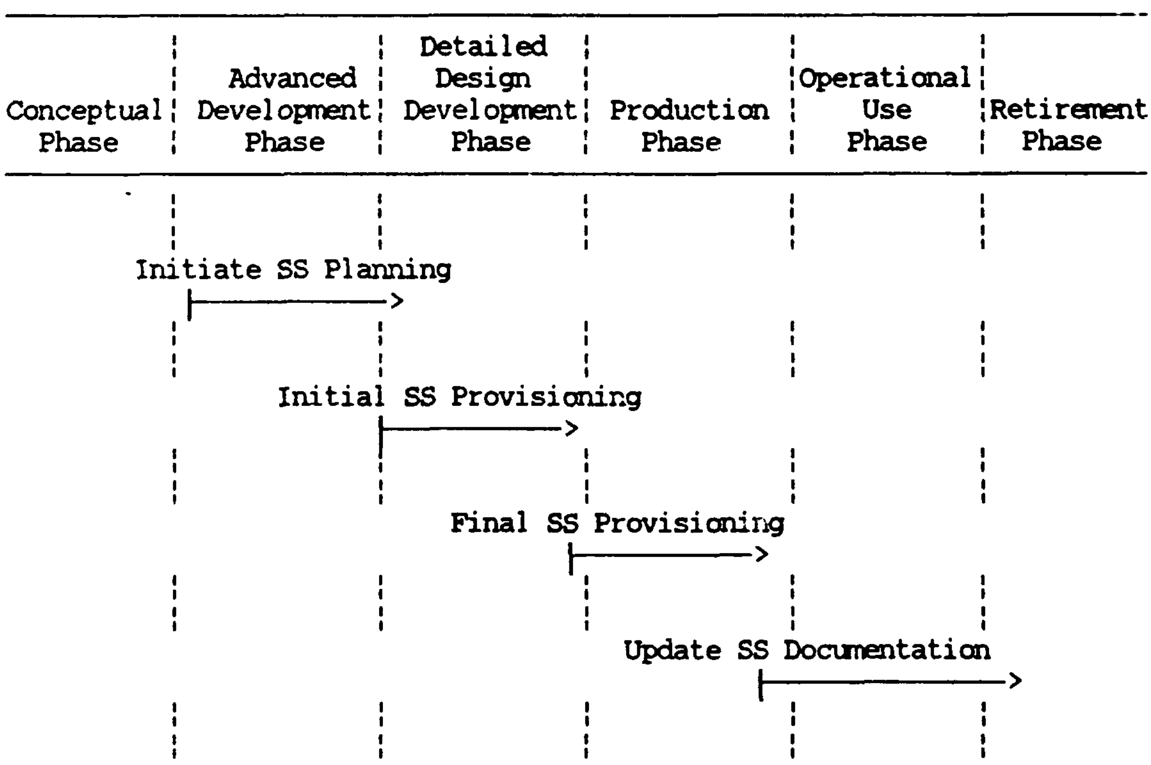


Figure 5. Supply Support(SS)/Life Cycle Relationship

associated with supply support. During the advanced development phase planning must take place to ensure parts obsolescence will not be a major problem later in the system life cycle. There is no real solution to the problem, but exchanging information between logistics support personnel and designers early in the life cycle will assure that the problem is not unsuspected (Stolinski, 1987:88).

Initial provisioning begins early in the detailed design and development phase. Provisioning in the future will change due to advancements in automated systems development (Klein, 1989:37-38). The requirement to provide spare parts for rapidly changing systems will test logistics managers in the future. Before transition into the production phase final provisioning and associated supply support documentation should be complete. Revisions to supply support continue throughout the entire life cycle in the form of hardware reconfigurations and operating data experience.

Support Equipment. This element takes into account the needed equipment to support the operations and maintenance of the system (ILS Guide, 1986:7-9). Figure 6 illustrates the support equipment element as it advances through the system life cycle phases.

Support equipment is an integral part of the complete system and must be planned and developed during the conceptual phase. The decision whether to purchase new

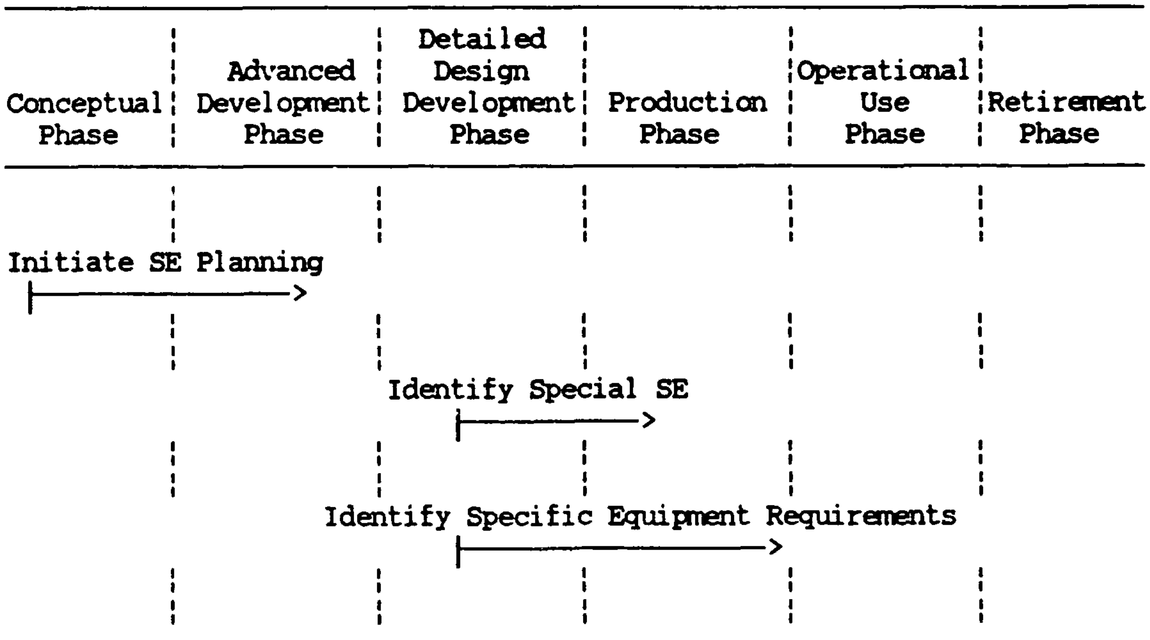


Figure 6. Support Equipment(SE)/Life Cycle Relationship

support equipment or use existing equipment must be made early in the system life cycle (ILS Guide, 1986:7-9).

Special support equipment should be identified midway through the detailed design and development phase. At this time "detailed task analyses and documentation are performed to identify the specific equipment requirements for every operating and maintenance task" (ILS Guide, 1986:7-9).

Technical Data. This element provides all the necessary technical information concerning the system being developed. Operations and maintenance manuals, specifications, drawings, and computer support material are included in this element. Figure 7 illustrates the technical data element as it advances through the system life cycle phases.

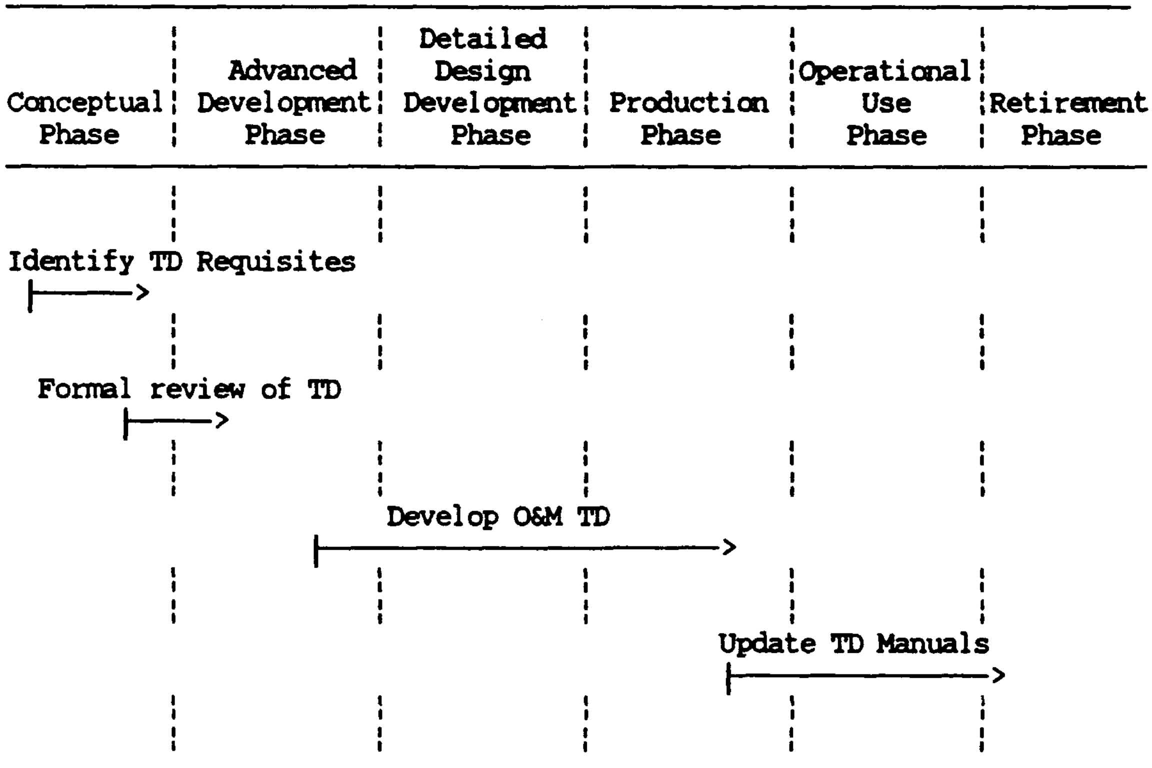


Figure 7. Technical Data(TD)/Life Cycle Relationship

Requisites for technical data should be identified in the conceptual phase. Both technical data, relating to operations and maintenance, and management data, to be used for audit procedures, must be developed during the advanced development phase (Finkelstein and Guertin, 1988:136). Preliminary manuals covering these types of data must be accessible late in the advanced development phase to support testing and training functions (ILS Guide, 1986:7-10). A formal review process of the technical data is necessary to ensure compliance with requirements set forth early in the conceptual phase. Updates to the technical data associated

with technological advancements to the system are made throughout the life cycle.

Training. The training element involves the methods, techniques, and resources used to prepare personnel to operate and maintain a given system. Figure 8 illustrates the training element as it advances through the system life cycle phases. "DODD 5000.39 specifies that detailed descriptions of current and projected skill and training resources be developed during the conceptual phase" (ILS Guide, 1986:7-10).

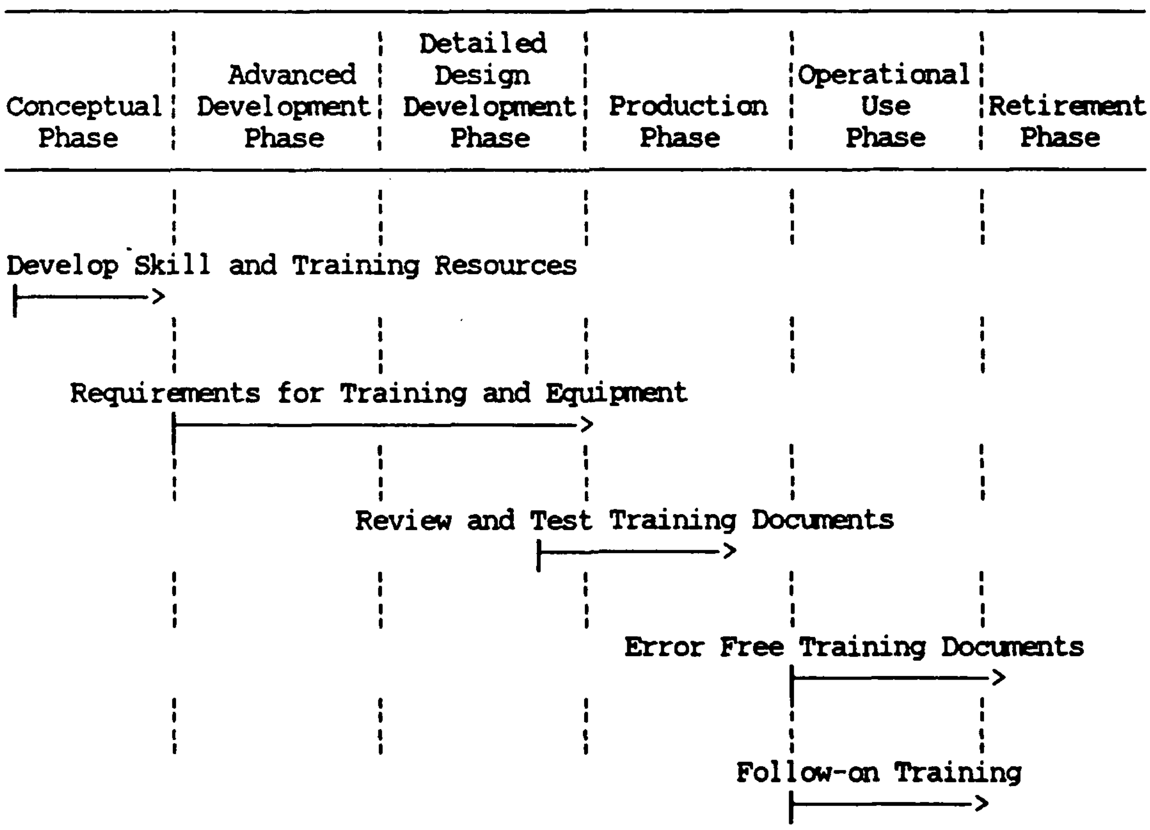


Figure 8. Training/Life Cycle Relationship

Requirements for training and equipment are performed during advanced development and detailed design and development phases (ILS Guide, 1986:7-10). The logistics manager must work with training personnel to ensure support requirements are outlined in the training material. The training documents shall be reviewed and tested during the later part of the detailed design and development phase or early in the production phase. The training documents should be free of any discrepancies when applied in the operational use phase. A cadre of operations and maintenance support personnel should be designated as follow-on trainers for additional personnel employed on the system after initial training is conducted (DOD/DMA DPS Handbook, 1989:65).

Computer Resources Support. The computer resources support element can be described as containing all hardware, software, documentation, contract support, personnel, and supplies required to operate and maintain a given automated system. With systems becoming increasingly more complex, this ILS element requires more attention. Figure 9 illustrates the computer resources support element as it advances through the system life cycle phases.

Both software and hardware development should begin early in the conceptual phase of the system life cycle. "Logistics engineers must begin to express their concerns as early as the idea stage of a program" (Klein, 1989:37).

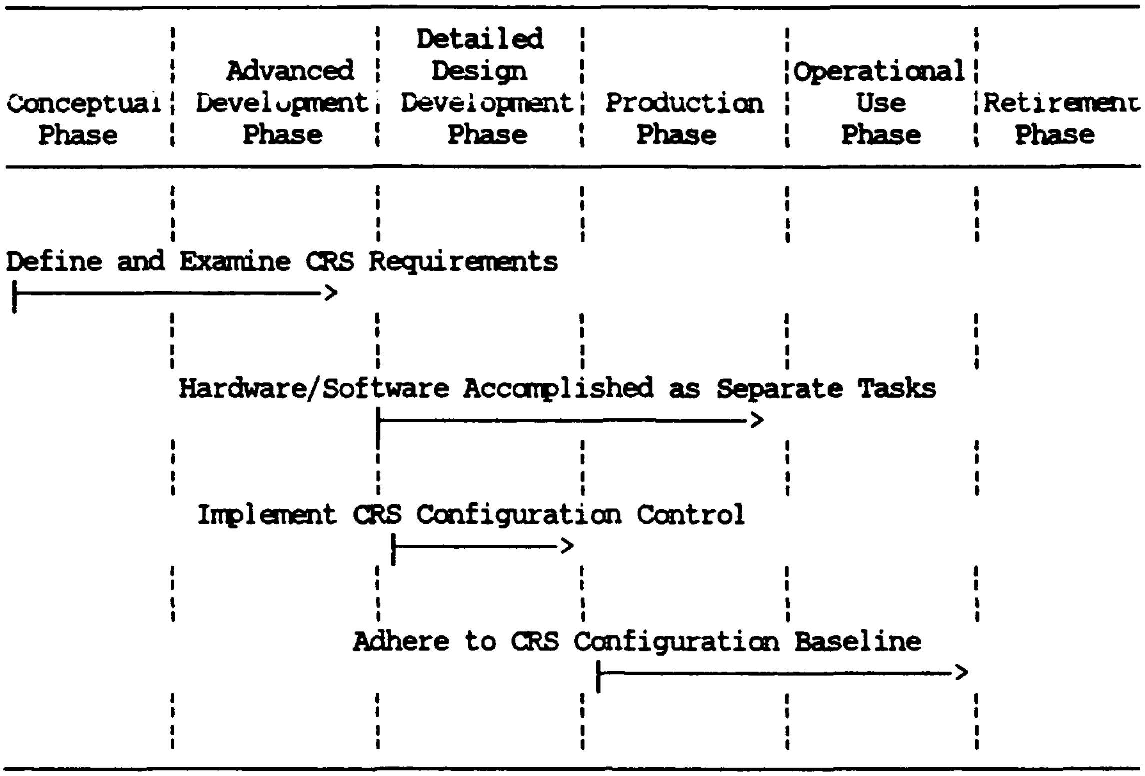


Figure 9. Computer Resources Support(CRS)/Life Cycle Relationship

During the conceptual phase and the advanced development phase system concepts are developed and system/software and system/hardware requirements are defined and examined (Tile, 1987:238). At the beginning of the detailed design and development phase hardware and software design and development are divided and accomplished as separate tasks. Hardware is designed to meet system specifications outlined in the conceptual phase and the logistics manager must ensure that the hardware design is congruent with other ILS elements. In the past, less attention was given to software supportability issues for automated systems than was given to hardware supportability issues (Tile, 1987:233).

The latest research indicates that software developers are spending more time fixing software rather than developing software (Haley, 1987:23). "Corporate programmers... now spend 80% of their time just repairing software and updating it to keep it running" (Klein, 1989:38). These reasons amplify why software support and the logistics managers must be part of the total design of the system during the detailed design and development phase. The same logistics considerations (modularity, transportability, and compatibility) that are designed for hardware must be designed for software (Finkelstein, 1988:204-205). Standard operating procedures and configuration control of software and hardware subsystems must be developed and implemented during the detailed design and development phase.

During the production phase and into the operational use phase adherence to the system configuration baseline provides the basis for future modifications (Finkelstein and Guertin, 1988:140). If changes are made to the baseline configuration, logistics managers must ensure proper documentation and software are updated to maintain effective system supportability.

Facilities. The facilities element has varying applications for governmental and private organizations. In the government, the facilities element captures both the real property assets required to support the system and the studies which define types of facilities or facility

improvements, locations, spare needs, etc. (ILS Guide, 1986:7-10). In private organizations, facilities consist of distribution systems/centers and warehousing operations. Figure 10 illustrates the facilities element as it advances through the system life cycle phases.

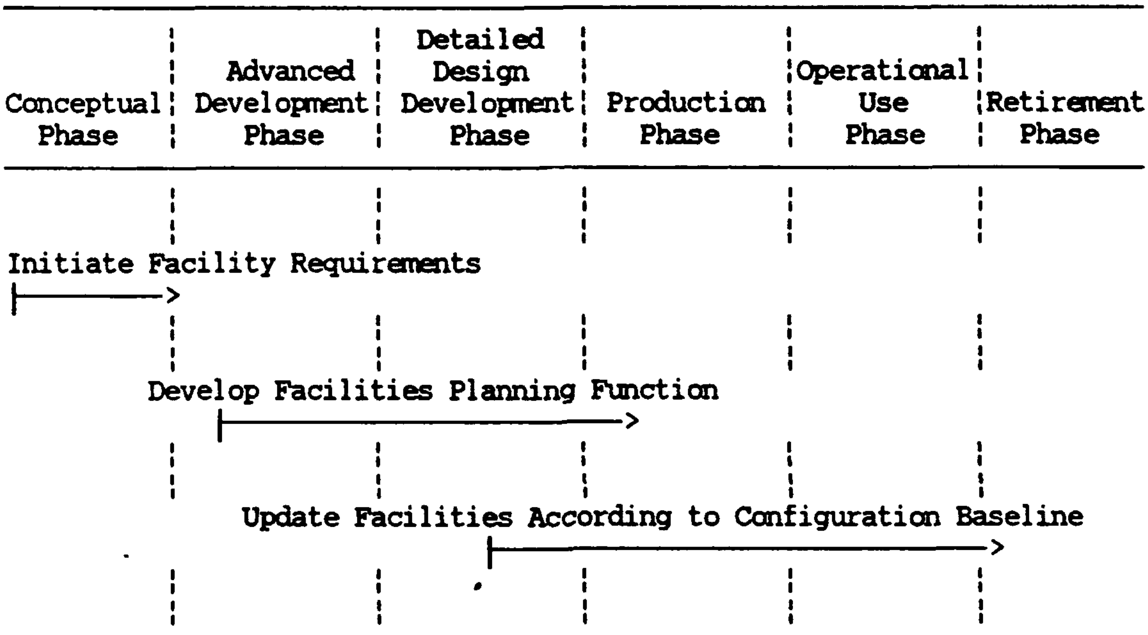


Figure 10. Facilities/Life Cycle Relationship

Determination of facilities' requirements in the private sector takes place early in the system life cycle because it is important to the distribution of a product to the customer (Finkelstein and Guertin, 1988:148). In the government, initial facility requirements are analyzed during the conceptual phase. This process must take place early in the system life cycle due to the constraints of the Six Year Program Objective Memorandum (POM).

During the advanced development phase the facilities planning function takes place. Input factors of the facilities planning function are existing facility data, projected space availability, funding constraints, and operations and maintenance concepts (ILS Guide, 1986:7-11). Updates to the facilities element, throughout the system life cycle, take place when system configuration baseline changes warrant.

Packaging, Handling, Storage and Transportation. The packaging, handling, storage and transportation (PHS&T) element "includes the characteristics, action and requirements necessary to insure the capability to transport, preserve, package, and handle equipment and support items" (ILS Guide, 1986:7-11). Figure 11 illustrates the PHS&T element as it advances through the system life cycle phases.

During the conceptual phase transportation requirements are analyzed against system objectives. Packaging and handling constraints for the system are also identified during the conceptual phase.

During the advanced development phase specific transportation attributes are identified to support system delivery after the production phase. Modes of transportation and carrier selection are criteria requiring special attention because of governmental deregulation of the transportation industry. During the advanced

Conceptual Phase	Advanced Development Phase	Detailed Design Development Phase	Production Phase	Operational Use Phase	Retirement Phase

Analyze Transportation Requirements

Identify packaging, handling, and storage constraints

Identify modes of transportation and carrier selection

Evaluate special requirements

Figure 11. Packaging, Handling, Storage and Transportation (PHS&T)/ Life Cycle Relationship

development phase special requirements concerning packaging and handling are evaluated and determined. Protection against environmental and transportation damage is essential for implementation of high technology automated systems.

<u>Design Interface</u>. The design interface element is the relationship of logistics-related design parameters, such as Reliability and Maintainability (R&M), to readiness and logistics support resource requirements (ILS Guide, 1986:7-12). R&M is the primary design interface parameter that will be evaluated in this research. Figure 12 illustrates the design interface element as it advances through the system life cycle phases.

Conceptual Phase	Advanced Development Phase	Detailed Design Development Phase	Production Phase	Operational Use Phase	Retirement Phase
Establish System Readiness Objectives					
Establish Logistics Constraints					
	Design Reliability and Maintainability Functions				

Figure 12. Design Interface/Life Cycle Relationship

System readiness objectives and logistics constraints are established during the conceptual phase. R&M, both functions of the design, must be considered during the advanced development phase. Reliability can be defined as "the probability that a system will perform the intended functions for a predetermined time interval in a planned environment" (Ostrofsky, 1977:176). It is a quantitative measure for predicting the probability of failure for all or part of a given system. This parameter is most important to the supportability of a system when it is designed into the system early in the life cycle. The higher the reliability during the advanced development phase, the less likelihood of having major increases in support requirements later in the life cycle (Finkelstein and Guertin, 1988:52).

A parameter of equal significance to reliability is maintainability. Maintainability is defined as the "probability that a failed system is restored to operable condition in a specified downtime in its intended environment" (Ostrofsky, 1977:179). Maintainability must be applied early in the design process to prevent high maintenance costs throughout the system life cycle (Finkelstein and Guertin, 1988:72).

The literature review substantiates the requirement for determination and design of ILS elements early in the system life cycle and the need to provide ILS updates throughout the system life cycle.

> Knowing that, on the average, the greatest amount of total Life Cycle Cost (LCC) dollars are spent on Operations & Maintenance (O&M), which really equates to logistics support, and that the vast percentage of total LCC is committed early in the acquisition process, it becomes apparent that logistics planning must begin at the front end of an acquisition program. (Materna and Andrews, 1988:5-4)

Conclusion

Automated cartographic or photogrammetric systems can be classified as high technology, fast obsolescence systems. Proper management, design, and support of these systems are required to maintain mission readiness. Logisticians must apply ILS techniques during the entire life cycle of automated cartographic or photogrammetric systems especially in the conceptual, advanced development, and detailed design and development phases. Coordination between logisticians and designers-engineers will lower support costs during the

operational use phase and throughout the remaining life cycle of the system.

Chapter III presents the methodology used in this research. This literature review provides the basis for developing the Delphi survey questions concerning logistics support for automated cartographic or photogrammetric systems.

III. Methodology

There has been little research performed concerning logistics support planning for automated cartographic or photogrammetric systems. As one of the largest users of these specialized systems, the Defense Mapping Agency (DMA) sponsored this research which addressed logistics support planning requirements for automated cartographic or photogrammetric systems.

The research design executed in this research effort encompassed three major phases. The first phase involved exploratory research to include a detailed literature review concerning the areas of management principles, system life cycle or design, and ILS. The second phase comprised the construction of a descriptive ILS planning model tailored to the DMA operating environment. The third phase validated the descriptive model through the application of a Delphi technique. These phases provided the data needed to answer the research questions formulated in Chapter I.

Literature Review

The literature review performed in Chapter II identified management principles, system life cycle or design processes, and ILS elements associated with automated cartographic or photogrammetric systems. These characteristics and attributes facilitated the construction of the instrument used in the Delphi survey.

Constructing the Model

The Delphi method provided the means for constructing a descriptive model by polling expert DMA administrative, research and development, support and maintenance, and production personnel and reaching a level of consensus on characteristics and attributes of a descriptive model applicable to automated cartographic or photogrammetric systems. These four primary functional areas formed the DMA expert population utilized in the two iterative rounds of the Delphi survey.

Selection of Research Technique. A particular field of research follows a developmental path as it progresses through the maturation cycle. In Figure 13, the arrow shows the directional path the field of research follows throughout maturity (Schendel and Cool, 1988:28).

The initial implementation of research begins in the prescriptive cell (see Figure 13, cell 1). Schendel and Cool summarized the prescriptive phase as:

> ... the worst of all research worlds depicted; where much work lies, mostly embodied in the form of untested, or worse, untestable, statements. (Schendel and Cool, 1988:28)

The descriptive phase of research methodology attempts to define the research problem (see Figure 13, cell 2). The process requires personal insight, judgement, and creativity with the results often serving as hypotheses which require further testing (Schendel and Cool, 1988:28).

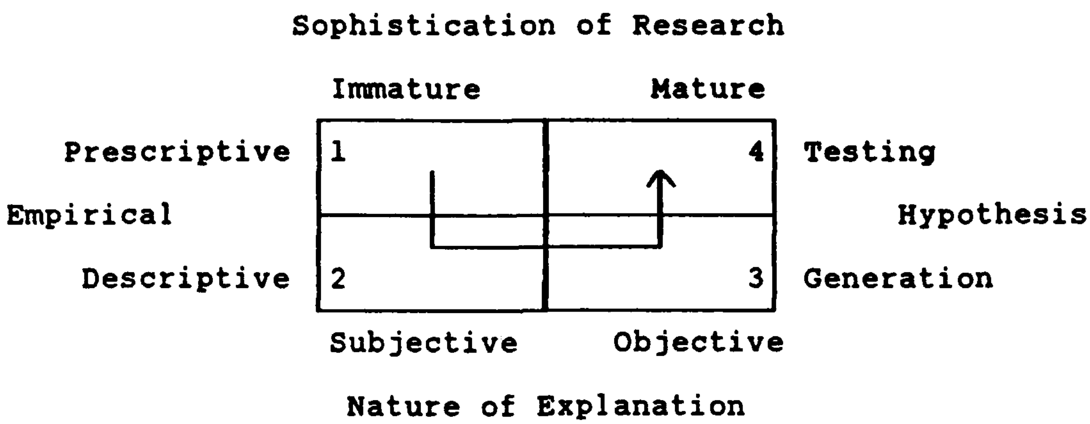


Figure 13. Maturation of Research in Scientific Method (Clark, 1989:103)

The hypothesis generation phase follows the subjective description of the research problem (see Figure 13, cell 3). The research performed in this phase depicts a meticulous, accurate description of the research problem (Schendel and Cool, 1988:28). In this phase, a precise description of the research problem often leads to excellent field research and complete data bases required to analyze the research results.

Hypothesis testing is the final phase of research methodology and the most optimal stage (see Figure 13, cell 4). Events such as testing hypotheses, developing causal models, and validating predictive theory occur during this phase (Schendel and Cool, 1988:29). Using statistical methods, this type of research "can guide practice and explain results achieved" (Schendel and Cool, 1988:29).

This research effort lies within the descriptive process of research methodology. Using the Delphi technique

to solicit DMA experts' opinions, a descriptive model portraying the logistics support requirements for automated cartographic or photogrammetric systems provided the boundaries of the research problem area (Schendel and Cool, 1988:28). The descriptive approach defined the parameters and allowed for further research in the logistics support planning area of automated cartographic or photogrammetric systems.

A review of the literature determined whether the Delphi technique of research methodology was appropriate for determining logistics support requirements for automated cartographic or photogrammetric systems.

> In order to comprehensively study the manifold issues involved in the application, usefulness, and future applicability of the Delphi method, it was necessary to capture the thoughts of those who were familiar with the method. (Brockhaus and Mickelson, 1977:104)

Brockhaus and Mickelson's research polled 312 individuals involved with the Delphi method. Of the 312 total respondents, 176 had experience with the Delphi method in the capacity of a project director, 59 individuals participated as panel members in Delphi studies, and 77 individuals possessed familiarity with Delphi, but had not been involved in any Delphi studies (Brockhaus and Mickelson, 1977:106). They divided their findings into the following five sections:

> (1) for what purposes and with what degree of success has the Delphi method been used; (2) how significant a development has the Delphi method been and how frequently is it utilized throughout the world in various substantive fields; (3) what will be the future

of the Delphi method; (4) how should the Delphi method be used in conjunction with other methodologies; (5) what types of organizations have financed Delphi studies; and (6) other considerations affecting the applicability of the Delphi method. (Brockhaus and Mickelson, 1977:105)

The first finding indicated the Delphi method has been successful when used for planning purposes associated with technological applications (Brockhaus and Mickelson, 1977:106). This type of application supports the selection and use of the Delphi method for determining logistical support requirements for automated cartographic or photogrammetric systems. When fully operational in the mid 1990s, DMA's automated cartographic or photogrammetric systems will provide state-of-the-art graphic and digital earth data products (DOD/DMA DPS Handbook, 1989:1).

Brockhaus and Mickelson's research revealed five substantive fields of application for Delphi studies (Brockhaus and Mickelson, 1977:106). Substantive fields, where the Delphi method has been used, are illustrated in Table 3. Logistics support requirements for automated cartographic or photogrammetric systems fall within the physical sciences/engineering field application of the Delphi method. Project directors who conducted two or more studies in the physical sciences/engineering field found the Delphi method to be a significant development within scientific/engineering research (Brockhaus and Mickelson, 1977:107).

Table 3

Number of Delphi Studies by Substantive Field

Substantive field	Number of studies reported	Percentage of total studies reported
Physical sciences/engineering	153	26%
Business/economics	139	23%
Social sciences	140	23%
Education/public administration	116	19%
Biological sciences/medicine	50	09%
Total	598	100%

(Brockhaus and Mickelson, 1977:106)

Forecasts revealed a moderate growth for Delphi studies in the physical sciences/engineering and business/economics fields and substantial growth for the social sciences and education fields (Brockhaus and Mickelson, 1977:107).

Brockhaus and Mickelson's research indicated certain methodologies should be applied prior to and after the implementation of the Delphi method. Brockhaus and Mickelson affirmed the need for both the

> ... development of an information database through a literature review prior to the Delphi application and model building following the Delphi survey. (Brockhaus and Mickelson, 1977:108)

The literature review conducted prior to the Delphi survey in this research effort provided an information database containing management principles, system life cycle or design processes, and ILS elements. The information

collected in the literature review provided the necessary data required to construct the Delphi survey. Following the Delphi survey, a descriptive ILS planning model was constructed and tailored to DMA automated cartographic or photogrammetric systems.

The cost and/or available funds to conduct this Delphi study had no bearing on the selection of the technique used for determining logistical support requirements for automated cartographic or photogrammetric systems. DMA identified the need for logistics management research in the cartography or photogrammetry field and funded the research through its Long-Term Full Time Training Program.

Brockhaus and Mickelson's research indicated most Delphi studies consist of three or less iterations (Brockhaus and Mickelson, 1977:109). The Delphi study associated with this research was limited to two iterations because of time limitations placed on the thesis effort.

The major reason for selecting the Delphi method was to gather expert opinion and bring the expected diversity of opinions to a convergence (Brockhaus and Mickelson, 1977:109). Although faced with time constraints, the Delphi method allowed for the participation of physically dispersed experts while maintaining a high degree of convergence (Preble, 1983:76). "In using the Delphi approach, numerous experts are solicited for their opinions on the future technology in a specified area" (Roberts, 1969-1970:113). The Delphi method, which polls DMA experts for their

opinions, attempted to reach a level of consensus on logistical support requirements needed to support and maintain technologically advanced automated cartographic or photogrammetric systems. The normative use of the Delphi technique identifies and orders the characteristics and attributes of the model developed (Preble, 1983:83).

Delphi Method. Jillson stated that the typical Delphi researcher is "The graduate student who worries that his thesis proposal seems a bit dull, and believes that there is no dissertation like a spiffy dissertation" (Jillson, 1975:221). The following discussion of the Delphi method refutes Jillson's notion of the typical Delphi user and explains why Delphi was applied to this research.

The Delphi technique employs a questionnaire for organizing and sharing opinion through feedback (Bardecki, 1984:281). The technique usually is accomplished through an iterative process in which experts are solicited for their opinions concerning the topic of research. Figure 14 illustrates the Delphi technique in closer detail.

The Delphi technique, as any other methodology, begins with problem definition. Having defined the research problem, the appropriate degree of expertise is determined for the Delphi survey respondents. Experts are selected possessing the knowledge to adequately provide opinion data and numerical feedback to survey questions. While preparing the survey questionnaire to address investigative research

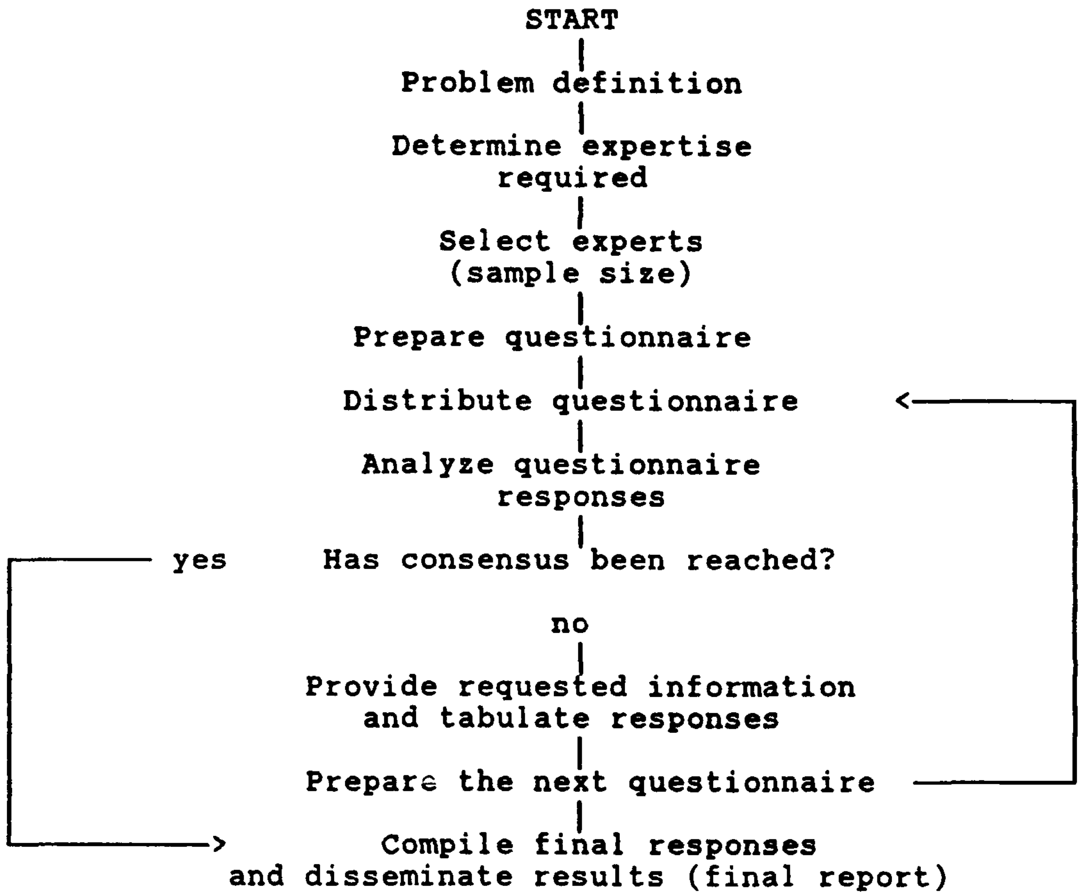


Figure 14. Delphi Process Flowchart
(Riggs, 1983:90)

questions, the participation of each selected respondent is confirmed by oral or written correspondence. Distributed questionnaires require thorough, accurate, and timely responses. Results from the first round of the survey are analyzed to determine if consensus has been reached. Non-consensus items and all opinion data from previous rounds of the survey are provided as feedback to the participants in successive rounds of the survey. "The process is continued in an iterative manner until consensus is reached" (Riggs,

1983:90). Final results of the survey should be provided to all Delphi participants.

Advantages of Delphi.

> The Delphi technique was developed at the RAND Corporation in 1950 by Dalkey and his associates to eliminate many of the negative effects related to the use of interacting groups for decision making. (Riggs, 1983:89)

Some of these negative effects of large group decision making were factors such as expense, conformity, and dominance of certain personnel. The Delphi process overcame the negative effects of group interaction decision making and provided features such as structured format, systematic procedures, clear communication, statistical feedback, and anonymity (Preble, 1983:75). While the Delphi technique exhibited several strengths, it also exhibited a number of distinct weaknesses.

Disadvantages of Delphi. The two primary disadvantages of Delphi applicable to this research, as in many other Delphi studies, were length of time and respondent selection. Delphi studies are extremely time consuming depending on the number of iterations performed and the amount of opinion data that must be collated and distributed to the respondents at each iteration. The time limitation of the Air Force Institute of Technology (AFIT) graduate logistics management program permitted only two iterations of the Delphi survey.

The opinion data collected in round one of the survey and distributed as feedback in round two of the survey

allowed respondents to consider data provided by other experts. In round two of the survey, respondents refuted opinions of others and provided additional comments to questions.

Population definition can be achieved relatively easily, but the actual respondent selection is difficult. Iterative interviews of senior DMA managers provided the DMA Delphi respondent group. This process is explained in more detail below on page 51. DMA experts selected for the Delphi survey provided accurate and timely responses in both rounds of the survey. A report of the research findings offered an incentive to respond because time was a valuable asset to the DMA experts. The methodological value of the Delphi process required examining the reliability and validity of the technique.

Reliability. "Reliability is concerned with estimates of the degree to which a measurement is free of random or unstable error" (Emory, 1985:98). In a discussion of Delphi method reliability Hill and Fowles asserted

> ... the reliability of Delphi forecasting is critically weakened by an absence of recognized administrative standards to guide Delphi implementation, along with an insufficiency of the methodological expertise which would be necessary to make up for the first deficit when a Delphi is actually executed. (Hill and Fowles, 1975:184)

Jillson supported this premise in her article "Developing Guidelines for the Delphi Method". She stated

> ... I would suggest that the time has come for guidelines or standards to be developed that can be applied to the review of Delphi proposals, or reports of findings resulting from Delphi studies. (Jillson, 1975:222)

Jillson recommended that these guidelines include some of the following:

> Standards for determining the applicability of the technique to the problem identified; criteria for selecting respondents; and recommendations for the interpretation f results. (Jillson, 1975:222)

Guidelines for determining the applicability of Delphi to the research problem were established earlier in this chapter. Iterative interviews of senior DMA managers provided criteria and names of appropriate DMA administrative, research and development, support and maintenance and production respondents (see page 51). Recommendations for the interpretation of research results were of a planning nature. The descriptive model developed from the survey served as a logistics support planning tool for automated cartographic or photogrammetric systems. Adherence to the guidelines proposed by Jillson ensured the reliability of the Delphi method employed in this research.

Validity. T'.e validity of the Delphi method can be examined in two ways: (1) data validity; and (2) internal validity (Hill and Fowles, 1975:185).

Data validity refers to the data that result from conducting the Delphi survey (Hill and Fowles, 1975:185). The selection of DMA experts and the qualitative and quantitative feedback from the experts provided the

necessary data to accurately determine logistical support requirements for automated cartographic or photogrammetric systems. The use of DMA experts in these automated systems ensured sufficient content validity in the research in that it provided adequate coverage of the topic under study (Emory, 1985:95).

Internal validity is "the ability of a research instrument to measure what it is purported to measure" (Emory, 1985:94). The literature provided both negative and positive viewpoints concerning the internal validity of the Delphi technique. Hill and Fowles expressed serious reservations regarding the achievability of internal validity through the use of the Delphi method as shown below.

> ... neither data nor internal validity have yet been demonstrated. Until they are, it is reasonable to remain skeptical, for certain characteristics of the method call any claims for validity into question. (Hill and Fowles, 1975:186)

In support of the internal validity of Delphi, Martino stated "there is a well-defined process at work in the production of Delphi forecasts" (Martino, 1972:299). Hills and Fowles also provided evidence in support of internal validity by stating

> ... other evidence advanced in support of internal validity is that from Dalkey's research employing students to "predict" almanac-type information (current detailed facts) or Campbell's use of Delphi for short-term estimates of the performance of economic indicators. (Hill and Fowles, 1975:186)

Population Definition. The population of the Delphi survey respondents comprised all employees of the Defense Mapping Agency associated with administrative, research and development, support and maintenance, and production activities for automated cartographic or photogrammetric systems. Appendix D illustrates the DMA organizational structure and the various office functions associated with administrative, research and development, support and maintenance, and production activities for automated cartographic or photogrammetric systems.

Delphi Respondents. Interviews were held with the Director, the Deputy Director/Operations Support Group, and the Deputy Director/Modernization Development Group of the DMA Systems Center to determine an initial list of possible Delphi respondents within the office functions identified in Appendix D. An iterative phone call inquiry process, starting with the initial list of possible Delphi respondents, led to the final selection of Delphi respondents for the survey.

Thirty-five DMA experts from administrative, research and development, support and maintenance, and production functions were selected from the population mentioned above. Thirty-one experts (89% response rate) participated in the Delphi survey. Table 4 illustrates the composition of the Delphi respondent group. The four functional areas selected are portrayed along the vertical axis of Table 4. These

Table 4

Delphi Respondents by Function and Office Symbol

Function	DMAHQ	DMASC	DMARC	DMAHTC	DMAAC	DMATSC	Total
Admin.	2	2	1	1		1	7
Research and Development	2	4	1	1	1		9
Support and Maintenance	1	6					7
Production		1	2	3	2		8
Total	5	13	4	5	3	1	31

functional areas comprise the sources of experts within DMA most appropriate to participation in this survey. Every effort was made to attain an equal representation from the four functional respondent groups. The horizontal axis depicts the six major office components within DMA. With the exception of DMA Systems Center (DMASC) and DMA Telecommunications Services Center (DMATSC), there was equal respondent representation. DMASC responsibilities include design, development, and maintenance for DMA automated cartographic or photogrammetric systems explaining the large representations in these two functional areas. The primary role of DMATSC is coordination of all telecommunications activities for DMA, rarely interrelated with cartographic or

photogrammetric applications which explains the low representation of this office in this research effort. The following descriptions provide the functional responsibilities of the six office components represented in the Delphi survey:

> DMA Headquarters (DMAHQ) provides high-level policy guidance and oversight to all components concerning administrative, research and development, support and maintenance, and production. (DOD/DMA DPS Handbook, 1989:59)
>
> The DMA Systems Center (DMASC) is responsible for the requirements definition, design, development, procurement, installation, transition, and maintenance of the Digital Production System as well as all other research and development activities, production line maintenance, and configuration management. (DOD/DMA DPS Handbook, 1989:59)
>
> The three DMA production centers, DMA Reston Center (DMARC), DMA Aerospace Center (DMAAC), and DMA Hydrographic Topographic Center (DMAHTC), support the Digital Production System development and transition activities primarily through two organizations: (1) Research and Engineering Directorate (RE) and (2) Production Programs Modernization Division (PPM). (DOD/DMA DPS Handbook, 1989:60)
>
> DMA Telecommunications Services Center (DMATSC) is responsible for the overall coordination of telecommunications activities across DMA and for operation and maintenance of the Integrated DMA Telecommunication System (IDTS). (DOD/DMA DPS Handbook, 1989:61)

The response base was supportive of the logistics support planning element for DMA. The Delphi survey solicited opinions from the four functional areas depicted in Table 4. Administrative functions for the offices identified in Appendix D participated in the survey with two notable exceptions. The Director of DMA retired from military service during the conduct of the first round of

the survey. The Director of DMA Aerospace Center (DMAAC) did not feel qualified to adequately address the questions in the survey because of his limited background in cartographic or logistics applications. There was only one research and development representative from DMA Reston Center (DMARC) because of the limited number of personnel available at the time of the study. DMA Telecommunications Services Center did not staff a research and development function; therefore, it had no functional representation for research and development. The Director of DMAHQ Facilities Engineering & Logistics Directorate and the Deputy Director of DMASC Operations Support Group did not participate because they were preoccupied with organizational changes at the time of the survey.

Support and maintenance functions were primarily located at DMA Headquarters (DMAHQ) and DMA Systems Center (DMASC) and the participant selections supported this fact. The production functions within DMA were located at the DMA Hydrographic/Topographic Center (DMAHTC), the DMA Aerospace Center (DMAAC), and the DMARC. These three offices were equally represented in the survey. One respondent was from DMASC, but has worked in his present position less than one year. He was selected based on his extensive experience in a production element gained elsewhere in DMA. Each respondent selected was contacted by phone and written correspondence to confirm participation prior to mailing the surveys.

Delphi Survey Construction. Delphi survey questions were developed from the data researched in the literature review. The survey, found in Appendix E, contained four sections pertaining to (1) personnel demographics; (2) basic characteristics of the Logistics Systems Management Matrix (LSMM); (3) unique factors of ILS elements associated with automated cartographic or photogrammetric systems; and (4) life cycle determination and design requirements of the ILS elements. Attachments 2 and 3 of the survey provided detailed descriptions of the design or life cycle phases and the ILS elements portrayed in the LSMM. The definitions provided a common basis of understanding for the respondents to ensure non-biased results from the questionnaire.

The survey consisted of multiple choice questions, scaled questions (Likert), rank order questions, and open ended questions that allowed the experts to provide opinions concerning logistical characteristics and attributes of automated cartographic or photogrammetric systems. A model was constructed from the responses received from DMA administrative, research and development, support and maintenance, and production experts.

The survey was pretested by four DMA experts within each of the functional areas. The responses from the pretest surveys aided in clarifying questions and providing attachments to assist the Delphi respondents in survey completion.

Data Analysis. Using the Delphi method, one continues the process in an iterative manner until consensus is reached (Riggs, 1983:90). Due to the limited time available to conduct the Delphi process for this research effort, a 60 percent agreement level was established as the consensus criterion (Gregor, 1988:40). Scaled, multiple choice, rank-ordered, and open-ended responses provided by the experts were subjected to the consensus criterion.

Mean responses were computed for the scaled questions. For Likert scale items requesting a scaled response "expressing either a favorable or unfavorable attitude" (Emory, 1985:255), "highly agree/agree" and "highly disagree/disagree" responses were grouped together in order to determine whether consensus was reached (Gregor, 1988:41). The other Likert scale item responses were not grouped together, but still were subjected to the 60 percent consensus rule.

For the non-Likert questions, frequencies were examined to determine if the 60 percent consensus existed. Means were computed for the items of one rank-ordered response. The items were ranked according to the means and also subjected to the 60 percent consensus rule. For the other rank-ordered responses a weighting factor was assigned to each response to determine the three MOST and LEAST important ILS elements associated with logistics support planning of automated cartographic or photogrammetric systems. The items were ranked according to the total value

computed for each ILS element and also subjected to the 60 percent consensus rule.

A list of factors, unique to automated cartographic or photogrammetric systems, was developed for each ILS element of the model in round one of the survey. In round two, the experts selected the three most important factors associated with automated cartographic or photogrammetric systems. Other comments included in round one were provided as feedback in round two to assist the experts in answering non-consensus items. Only those questions with less than 60 percent consensus agreement were asked again in round two. However, mean and percent of consensus agreement for all questions were provided as feedback.

Validating the Model

The model constructed was validated by using the iterative Delphi process. The survey process determined if DMA management believed the characteristics and attributes of the model were valid for DMA's high-technology, fast-obsolescence systems. In round one of the survey, the DMA experts reached consensus on the three dimensions of the descriptive model. The opinion data also supported the dimensions of the model. The descriptive model validated by DMA experts was identical to Ostrofsky's Logistics Systems Management Matrix (LSMM) presented in Chapter II with one exception. Security was added to the ILS elements dimension of the model from opinion responses provided by the experts.

Conclusion

The Defense Mapping Agency recognized the need to identify logistics support planning requirements for automated cartographic or photogrammetric systems. In an area of research defined as prescriptive, at best, it was imperative to establish parameters for investigating the research problem. The Delphi method provided the technique required to develop a descriptive model portraying the logistics support requirements for automated cartographic or photogrammetric systems. Two iterations of the Delphi survey were performed using DMA experts employed in administrative, research and development, support and maintenance, and production functional activities. The results of the Delphi process are found in the following chapter.

IV. Results

The results chapter describes the results obtained from the Delphi survey conducted in this research. The Delphi survey of 35 DMA experts (administrative, research and development, production, operations support and maintenance) consisted of two iterative rounds of questions to determine (1) if DMA experts could reach a level of consensus on the characteristics and attributes of a logistics support model applicable to automated cartographic or photogrammetric systems; (2) what factors within the ILS elements were unique and applicable to automated cartographic or photogrammetric systems; and (3) at what stages of the automated system's life cycle did the ILS elements require determination and design? Based on the Delphi survey results, a descriptive model was developed to address the logistical support requirements for automated cartographic or photogrammetric systems.

Delphi Survey

The purpose of the Delphi survey was to verify the management principles, system life cycle or design processes, and ILS elements used in Ostrofsky's Logistics Systems Management Matrix (LSMM) and determine what characteristics or attributes associated with automated cartographic or photogrammetric systems should be included

in the model. The survey consisted of two separate iterative rounds of questioning.

The round one questionnaire (Appendix E) contained the following four topic areas of consideration (1) background information; (2) basic characteristics of the LSMM model; (3) unique factors of ILS elements associated with automated cartographic or photogrammetric systems; and (4) life cycle determination and design requirements of the ILS elements. Round one of the survey consisted of 19 multiple choice questions, six scaled questions (Likert), two rank order questions, and 17 open ended questions requesting the experts to specify logistical characteristics and attributes of automated cartographic or photogrammetric systems. Responses from some open ended questions provided in round one served as input for constructing follow-on questions used in round two of the Delphi survey. The Delphi respondents also included many additional comments throughout the survey. Those comments provided in round one of the survey are found in Appendix F.

The round two questionnaire (Appendix G) contained three of the four topic areas which were found in round one of the Delphi survey. The topic area of background information, which contained demographic data on the survey participants, was not repeated in round two. Not all questions required answers in the second round because consensus was reached in the first round of the Delphi survey. As stated in Chapter III, the criterion for

consensus was established at 60% agreement on a single response item. The percent of consensus agreement was provided for each answer.

The questions which required a new response in round two were asterisked on the survey questionnaire and accompanied by the statement "Your New Response" (see Appendix G). For multiple choice, scaled, and rank order questions, mean ratings and/or comments from round one were provided to assist the respondent in completing non-consensus questions. For each ILS element a list of factors unique to automated cartographic or photogrammetric systems was collated from round one open-ended responses. Each participant reviewed the list and provided the three most important factors, for each ILS element, that he/she felt were unique to automated cartographic or photogrammetric systems. Additional comments provided in round two of the survey are provided in Appendix H.

Round One Results

The response rate from round one of the Delphi survey was 89% with participation from 31 of 35 DMA administrative, research and development, production, operations support and maintenance experts. Appendix I lists the respondents by name and organizational component. The numerical responses and open-ended comments provided by the experts were of great value in the research effort. Round one of the survey

was divided into four topic areas as mentioned above. The experts' responses to these topic areas are examined below.

Background Information. For the total respondents (N = 31), the functional responsibilities of the experts were evenly distributed. Table 5 illustrates that seven DMA administrative, nine research and development, eight production, and seven operations support and maintenance experts took part in round one of the Delphi survey.

Table 5

Functional Roles of Delphi Experts -- Round One Delphi Survey

Code	Category	Frequency
1	Administrative	7
2	Research and Development	9
3	Operational Use (Production)	8
4	Support and/or Maintenance	7
	TOTAL	31

Table 6 depicts the organizational representation of the Delphi respondents. The largest organizational response was from the Defense Mapping Agency Systems Center (DMASC). Many of the Delphi respondents are assigned to DMASC where there are large research and development, and operations support and maintenance functional responsibilities.

Table 7 illustrates that the dominant age group of the Delphi respondents was between 41 and 50 years. All 31

Table 6

Organizational Representation of Delphi Experts -- Round One Delphi Survey

Code	Category	Frequency
1	DMA Headquarters	5
2	DMA Systems Center	13
3	DMA Reston Center	4
4	DMA Hydrographic/Topographic Center	5
5	DMA Aerospace Center	3
6	Other (Telecommunication Services Center)	1
	TOTAL	31

Table 7

Age of Delphi Experts -- Round One Delphi Survey

Code	Category	Frequency
1	Less than 30 years	0
2	31 to 40 years	10
3	41 to 50 years	17
4	51 to 60 years	4
5	More than 60 years	0
	TOTAL	31

respondents were over the age of 30 and 21 (67.7%) of the respondents were over the age of 40.

Table 8 illustrates that all of the DMA experts who responded had at least a bachelor's degree with 74% having a graduate degree of higher level of education.

Table 8

Education Level of Delphi Experts -- Round One Delphi Survey

Code	Category	Frequency
1	High school graduate or GED	0
2	Some college work	0
3	Associate degree	0
4	Bachelors degree	3
5	Some graduate work	5
6	Master's degree	8
7	Master's degree plus	13
8	Ph. D. or equivalent	2
	TOTAL	31

Table 9 illustrates how long the Delphi experts have been associated with automated cartographic or photogrammetric systems. Nearly 40% of the respondents had 20 or more years of experience with DMA related systems.

Table 9

Automated Cartographic or Photogrammetric Experience of Delphi Experts -- Round One Delphi Survey

Code	Category	Frequency
1	Less than 4 years	5
2	4 years, but less than 8 years	4
3	8 years, but less than 12 years	4
4	12 years, but less than 16 years	4
5	16 years, but less than 20 years	2
6	20 years or more	12
	TOTAL	31

Table 10 illustrates the number of Delphi experts with experience as a user of DMA automated cartographic or photogrammetric systems outside of DMA. Only four respondents (13%) indicated experience with DMA automated cartographic or photogrammetric systems outside of DMA. Nearly all the Delphi experts' experience with automated cartographic or photogrammetric systems has been acquired while employed with DMA.

Table 10

Delphi Experts' Experience as User of DMA Automated Cartographic or Photogrammetric Systems Outside of DMA -- Round One Delphi Survey

Code	Category	Frequency
1	Yes	4
2	No	27
	TOTAL	31

Table 11 illustrates the length of time the Delphi experts have been employed at DMA. The frequency distribution in this table is nearly identical to the ranges of experience in automated cartographic or photogrammetric systems reported in Table 9.

Table 12 illustrates how long the Delphi experts have worked in their present position. Nearly 52% of the experts worked in their present position less than two years, while 90% worked in their present position less than four years.

Table 11

Length of DMA Employment of Delphi Experts
-- Round One Delphi Survey

Code	Category	Frequency
1	Less than 4 years	6
2	4 years, but less than 8 years	4
3	8 years, but less than 12 years	5
4	12 years, but less than 16 years	2
5	16 years, but less than 20 years	2
6	20 years or more	12
	TOTAL	

Table 12

Length of Time in Present Position of Delphi Experts
-- Round One Delphi Survey

Code	Category	Frequency
1	Less than 1 year	8
2	1 year, but less than 2 years	8
3	2 years, but less than 3 years	6
4	3 years, but less than 4 years	6
5	4 years, but less than 5 years	2
6	5 years or more	1
	TOTAL	31

Table 13 illustrates the various DMA organizations in which the Delphi experts had experience. There were eleven respondents who indicated they had experience in more than one of the organizations within DMA. There were only three respondents who indicated they had no other organizational

Table 13

Organizational Experience Within DMA of Delphi Experts -- Round One Delphi Survey

Code	Category	Frequency
1	DMA Headquarters	10
2	DMA Systems Center	8
3	DMA Reston Center	3
4	DMA Hydrographic/Topographic Center	16
5	DMA Aerospace Center	9
6	Other Telecommunication Services Center (1) Combat Support Center (1)	2
7	More than one organization	11
8	None	3
	TOTAL	62

experience other than their present position. The data in tables 12 and 13 suggest that the DMA experts were functionally mobile and received much of their experience in two or three DMA organizational components.

Basic Characteristics of the LSMM Model. The basic characteristics of the LSMM model were divided into three subject areas. These are (1) the basic structure of the model as it applies to the logistics support of automated cartographic or photogrammetric systems; (2) the design or life cycle processes of the model; and (3) the ILS elements portrayed in the model. There was not a separate subject area for the principles of management ("X" axis of the LSMM model) as it was defined to be outside the scope of this study (see Scope and Limitations section of Chapter I) .

The responses to the Likert scale questions concerning the basic characteristics of the LSMM model are displayed in Table 14. Responses to multiple choice and rank-ordered questions concerning the basic characteristics of the LSMM model are provided throughout this section. Some experts' comments are highlighted in the text while all comments provided in round one of the Delphi survey are found in Appendix F.

Table 14

Likert Responses
for the
Basic Characteristics of the LSMM Model
-- Round One Delphi Survey

Topic	Ratings 1	2	3	4	5	Mean	Consensus
Basic Structure	0	0	6	23	2	3.87	81% agree
Design or Life Cycle							
Basic Understanding	0	0	0	18	13	4.42	100% agree
Model Portrayal	1	5	4	19	1	3.47	65% agree
ILS Basic Understanding	0	0	2	18	11	4.29	94% agree
Model Portrayal	3	6	6	12	3	3.20	

Legend for Ratings

5 = highly agree
4 = agree
3 = neither agree nor disagree
2 = disagree
1 = highly disagree

Basic Structure. Eighty-one percent of the DMA experts agreed that the LSMM provided the basic structure for outlining the logistics support of automated cartographic or photogrammetric systems (see Table 14). The experts were asked how they would change the LSMM. One expert felt the "Z" axis should be reversed to depict the same origin as the "X" and "Y" axes. Another expert thought a new phase entitled "transition" should be added on the "Y" axis between production and operational use.

Design or Life Cycle Processes. The experts unanimously agreed that an understanding of design or life cycle processes was important for logistics support planning of automated cartographic or photogrammetric systems (see Table 14). Although consensus was reached for the question concerning the model accurately portraying the design of life cycle phases of automated cartographic or photogrammetric systems employed by DMA, the percentage agreement was only 65% (see Table 14).

The experts were asked to rank order, from one to six with "1" being the most important, the design or life cycle phases in terms of importance for logistics support planning of DMA automated cartographic or photogrammetric systems. Using the mean/rank method, the mean responses from round one were ranked from one to six. The only consensus response was retirement, which was ranked sixth. Table 15 displays the six design or life cycle phases, the rank order

Table 15

Design or Life Cycle Phases
of the LSMM Model
-- Round One Delphi Survey

Phase	Rank Order Frequencies 1	2	3	4	5	6	Mean or Consensus
Detailed Design	9	6	13	1	2	0	2.39
Advanced Development	7	12	1	9	2	0	2.58
Production	2	5	8	14	2	0	3.29
Operational Use	5	5	6	5	10	0	3.32
Conceptual	8	2	3	2	12	4	3.65
Retirement	0	1	0	0	3	27	87% agree

frequencies, and the round one mean or percentage agreement for each phase.

The experts were questioned on how they would change the design or life cycle phases proposed in the LSMM. Some experts thought the design or life cycle phases should be changed to reflect DMA terminology while others thought the terminology should have been DOD specific. Another expert stated

> ... the operational phase is conceived as merely being the use of the "product". In reality, life cycle phases 1-4 normally continue to reoccur repeatedly throughout the operational life of automated cartographic and photogrammetric systems. In my experience seldom if ever has a production system been the same "product" at the end of its life cycle as was envisioned at the start of its operational use.

Integrated Logistics Support (ILS) Elements. The experts reached a level of consensus (94% agreement) that an understanding of Integrated Logistics Support processes was important for logistics support planning of automated cartographic or photogrammetric systems (see Table 14). Responses were mixed (Round one mean 3.20) on whether the model accurately portrayed the ILS elements applied to automated cartographic or photogrammetric systems employed by DMA (see Table 14).

For the ten ILS elements portrayed in the LSMM model, the experts were asked to rank the three most important and the three least important ILS elements associated with logistics support planning of automated cartographic or photogrammetric systems.

In Table 16, the rank order frequencies of the three most important ILS elements were shown using "1" to denote the first, "2" to denote the second, and "3" to denote the third most important ILS element. A weighting factor was assigned to each response to determine the three MOST IMPORTANT ILS elements associated with logistics support planning of automated cartographic or photogrammetric systems. A value of five was assigned to each ILS element with a "1" response; a value of three was assigned to each ILS element with a "2" response; and a value of one was assigned to each ILS element with a "3" response. The total value of each ILS element was used to determine the overall ranking, from TOP TO BOTTOM, of the MOST IMPORTANT ILS

Table 16

Most Important ILS Elements
of the LSMM Model
-- Round One Delphi Survey

ILS Elements	Rank Order Frequencies 1	2	3	Value or Percent Consensus
Maintenance Planning	19	3	4	62% agree
Manpower/Personnel	4	10	4	54
Training	3	5	6	35
Supply Support	1	4	6	23
Design Interface	2	2	2	18
Technical Data	2	1	3	16
Computer Resources Support	0	3	1	10
Facilities	0	2	3	9
Support Equipment	0	1	2	5
Packaging, Handling, Storage and Transportation	0	0	0	0

ELEMENTS (see Table 16). The only consensus response was maintenance planning, which was found to be the most important or ranked first.

In Table 17, the rank order frequencies of the three least important ILS elements were shown using "8" to denote the eighth, "9" to denote the ninth, and "10" to denote the tenth least important ILS element. A weighting factor was assigned to each response to determine the three LEAST IMPORTANT ILS elements associated with logistics support

Table 17

Least Important ILS Elements
of the LSMM Model
-- Round One Delphi Survey

ILS Elements	Rank Order Frequencies 10	9	8	Value or Percent Consensus
Packaging, Handling, Storage and Transportation	17	7	4	110
Design Interface	9	4	5	62
Facilities	2	6	7	35
Computer Resources Support	3	2	3	24
Support Equipment	0	4	3	15
Supply Support	0	4	3	15
Manpower/Personnel	0	3	0	9
Technical Data	0	0	2	2
Training	0	0	0	0
Maintenance Planning	0	0	0	0

planning of automated cartographic or photogrammetric systems. A value of five was assigned to each ILS element with a "10" response; a value of three was assigned to each ILS element with a "9" response; and a value of one was assigned to each ILS element with an "8" response. The total value of each ILS element was used to determine the overall ranking, from TOP TO BOTTOM, of the LEAST IMPORTANT ILS ELEMENTS (see Table 17). There were not any consensus responses in round one of the Delphi survey.

The experts were asked if any of the ILS elements were not applicable to automated cartographic or photogrammetric systems and why did they lack applicability. Some experts believed that certain elements were not applicable. Specific comments were directed at the applicability of the design interface and manpower/personnel elements found in the model. One expert stated "the design interface is often not applicable because much of the hardware is Commercial Off-the-Shelf (COTS) and we have little input into its design". Concerning manpower and personnel, an expert stated

> ... manpower/personnel may not be applicable in the DMA environment because of our structured environment. The time frames involved in justifying and staffing new positions, particularly in a time of declining budgets makes it difficult to get the people needed in the time frame involved.

Another expert presented an opposing viewpoint concerning the applicability of the ILS elements. The expert stated

> ... if anyone says an ILS element is not applicable to automated cartographic or photogrammetric systems I would discount his/her entire survey - the individual obviously doesn't comprehend ILS.

Asked if they would change any of the ILS elements or add any elements to the LSMM model, some experts responded that security is a major issue and security support should be added as a separate ILS element. Another expert added that ILS usually references safety as part of the documentation and needs to be added to the model. Critical to the model an expert stated

> ... the model fails to recognize the fundamental nature of these systems, which is that they are a part of a production process. These processes and the systems necessarily change and evolve as improvements are made to increase productivity and as new or changed products are introduced into the production line. Automated cartographic or photogrammetric systems evolve during their life cycle so that they are often very different from their initial configuration and use in operation. Changes are made in both system hardware and software to effect this evolution. The ability to constantly modify applications software is particularly crucial to the production use of these systems. Applications software is very much an extension of the cartographer or photogrammetrist. It is probably not useful or meaningful to try to separate conceptually software maintenance from software development or enhancement. The problem with the model is that it is linear, when the actual life cycle for these systems involves an iterative development and operational cycle.

The final question presented to the experts in the basic characteristics of the LSMM model portion of the survey pertained to the extent to which DMA employed ILS in logistics support requirements planning of automated cartographic or photogrammetric systems (see Table 18).

Table 18

Extent of ILS Planning for DMA
Automated Cartographic or Photogrammetric Systems
-- Round One Delphi Survey

	Frequencies						
Topic	1	2	3	4	5	Mean	Consensus
Extent of ILS Planning	2	7	16	4	0	2.76	

Legend for Frequencies

1 = No extent at all
3 = To a moderate extent
5 = To a very great extent

The experts responded on a scale from one to five, with "1" representing to no extent at all, "3" representing to a moderate extent, and "5" representing to a very great extent. Table 18 presents the response frequencies and the round one mean. Consensus was not reached for this question in round one of the survey.

Unique Factors of ILS Elements. In the third section of the survey, each Delphi expert provided comments on what factors, within each of the ILS elements portrayed in the LSMM model, were unique and required logistics support planning for automated cartographic or photogrammetric systems. For each ILS element a list of factors unique to automated cartographic or photogrammetric systems was collated from round one responses. Table 19 provides a sample list of factors unique to automated cartographic or photogrammetric systems. Complete lists of factors were arranged by ILS element and displayed in Appendix J (Tables 39 through 48).

Life Cycle Determination and Design Requirements. The fourth section of the survey required experts to complete questions concerning when in the life cycle of automated cartographic or photogrammetric systems should determination and design requirements for each ILS element take place. The experts responded on a scale from one to five, with "1" representing the conceptual phase, "2" representing the advanced development phase, "3" representing the detailed design and development phase, "4" representing the

Table 19

Sample List of
Supply Support Factors Unique
to
Automated Cartographic or Photogrammetric Systems
-- Round One Delphi Survey

1. Adequate shelf stock of required parts
2. COTS equipment has impact on the provisioning process, proprietary data rights, and basic supply support concept
3. Dependent on local purchase due to unique spares not being stocked in DOD supply system
4. Hardware life cycle is over before systems are in full production
5. Initial spare start-up quantities
6. Large computer maintenance contracts
7. Optical components
8. Staging of spares
9. Steady state life cycle spare requirements
10. Tapes, removable drives, plotter pens, plotter paper
11. Unique systems need unique spares, requiring long lead time

production phase, and "5" representing the operational use phase. Table 20 lists the ILS element, the life cycle response frequencies, and the round one mean or consensus percent agreement.

The experts could not reach consensus on when in the life cycle determination and design requirements for the maintenance planning, manpower/personnel, computer resources support, facilities, and design interface elements should take place. The round one means for these elements were displayed in Table 20. The experts did reach consensus on when in the life cycle determination and design requirements for the supply support, support equipment, technical data,

Table 20

Life Cycle Determination and Design Requirements for ILS Elements -- Round One Delphi Survey

ILS Elements	Life Cycle Response Frequencies 1	2	3	4	5	Mean or Consensus
Maintenance Planning	4	16	6	2	0	2.21
Manpower/Personnel	3	8	17	1	0	2.55
Supply Support	0	5	21	3	0	68% agree
Support Equipment	0	7	21	2	0	68% agree
Technical Data	3	3	19	3	0	62% agree
Training	0	3	23	5	0	74% agree
Computer Resources Support	3	13	13	1	0	2.40
Facilities	3	12	15	0	0	2.40
Packaging, Handling, Storage and Transportation	1	0	22	6	0	71% agree
Design Interface	5	12	8	2	0	2.26

Legend for Life Cycle Response Frequencies

1 = Conceptual phase
2 = Advanced development phase
3 = Detailed Design and Development phase
4 = Production phase
5 = Operational use phase

training, and packaging, handling, storage, and transportation elements should take place. The experts agreed that each of these elements required determination and design during the detailed design and development phase (see Table 20).

The last question presented to the experts in round one of the Delphi survey was open-ended and pertained to how well DMA applies ILS or any other logistics support planning process to automated cartographic or photogrammetric systems. Most comments provided by the experts were similar to the following:

> ... the one area that DMA historically has ignored is the application of ILS during the conceptual phase of development rather than at the, too typically, unfortunately, operational phase. MARK 85 and MARK 90 systems are examples of how DMA is changing with respect to ILS. DMA needs to follow the formal processes of the life cycles of systems in a more rigorous manner for all systems, as is being done for MARK 90.

Another expert stated

> ... we take too long to start the process, as a result ILS doesn't do what it is intended to do (decisions have already been made).

Round Two Results

The response rate for round two of the Delphi survey was 81% (25 of 31) for those participants from the first round and 71% (25 of 35) for the original survey respondent group. Only round one Delphi respondents were mailed a round two survey questionnaire. The numerical responses and open-ended comments provided by the experts in round two continued to be of great value in the research effort.

Feedback from round one results of the survey was provided to the experts in round two. Delphi respondents were asked to complete questions in the following three areas: (1) basic characteristics of the LSMM model;

(2) unique factors of ILS elements associated with automated cartographic or photogrammetric systems; and (3) life cycle determination and design requirements of the ILS elements. The experts' responses to these areas are reviewed below.

Basic Characteristics of the LSMM Model. The experts again were asked to provide numerical responses and comments on the three subject areas which pertained to the basic characteristics of the LSMM model. These were (1) the basic structure of the model as it applies to the logistics support of automated cartographic or photogrammetric systems; (2) the design or life cycle processes of the model; and (3) the ILS elements portrayed in the model.

The responses to the Likert scale, multiple choice and rank-ordered questions concerning the basic characteristics of the LSMM model are displayed throughout this section. Select round two experts' comments are highlighted in the text and all comments provided in round two of the Delphi survey are found in Appendix H.

Basic Structure. After reviewing round one comments, the Delphi experts were asked again to provide comments on how they would change the LSMM. One expert refuted some of the round one comments and stated

> ... disagree with adding resources = $$. Resources are a limiting factor to the individual categories as well as to the model as a whole. "Transition is not a separate logistics step; one could put a "transition" step between every life cycle phase. Test equipment should not be a separate element because it is a type of "support equipment". DMA should use DOD terminology rather than its own.

Another expe t supported the consensus agreement that the LSMM provides a basic structure for outlining the logistics support of automated cartographic or photogrammetric systems. The expert stated

> ... there is nothing wrong with the LSMM model. It is only how the LSMM model is implemented - that is the problem.

<u>Design or Life Cycle Processes</u>. The experts were asked again to rank the five design or life cycle phases in terms of importance for logistics support planning of DMA automated cartographic or photogrammetric systems. Round one results showed the only consensus response was retirement, which was ranked sixth. For the remaining five design or life cycle phases, the experts were provided round one response means as feedback. Table 21 displays the six design or life cycle phases, the round two rank order frequencies, and the round two mean or percentage agreement for each phase.

Consensus agreement was reached for the conceptual phase in round two of the survey (see Table 21). The conceptual phase was ranked fifth in terms of importance for logistics support planning of DMA automated cartographic or photogrammetric systems. Although consensus was not reached for the remaining life cycle phases, the round one and two means showed detailed design and development was ranked first, advanced development second, production third, and operational use fourth (see Tables 15 and 21).

Table 21

Design or Life Cycle Phases
of the LSMM Model
-- Round Two Delphi Survey

Phase	Rank Order Frequencies 1	2	3	4	5	6	Mean or Consensus
Detailed Design	11	8	4	2	0	0	1.88
Advanced Development	5	10	5	3	2	0	2.48
Production	2	3	6	12	2	0	3.36
Operational Use	1	4	8	6	6	0	3.48
Conceptual	6	0	2	2	15	0	60% agree
Retirement	Round one consensus:						87% agree

Experts were asked again to provide comments on how they would change the design or life cycle phases proposed in the LSMM. Their comments supported the agreement reached in round one that the model portrayed the design or life cycle phases of DMA automated cartographic or photogrammetric systems. Other comments focused on the design or life cycle terminology used in the LSMM.

One expert suggested that the design or life cycle phase terminology used in the LSMM model be changed to DMA terminology. Table 22 presented the equivalent comparison of life cycle terminology suggested by the expert. Other experts agreed the life cycle terminology should adhere to DOD life cycle phase terminology.

Table 22

DMA Terminology
for
Life Cycle Phases Portrayed in LSMM Model
-- Round Two Delphi Survey

<u>LSMM Terminology</u>		<u>DMA Terminology</u>
Conceptual	=	Design Concept
Advanced Development	=	Preliminary Design
Detailed Design	=	Critical Design
Production	=	Build
(No Counterpart)	=	Transition
Operational Use	=	Production Operations
Retirement	=	Excessing

<u>Integrated Logistics Support (ILS) Elements</u>. In round one experts agreed (94%) that understanding ILS was important for logistics support planning of automated cartographic or photogrammetric systems. However, the experts could not reach a level of consensus on whether the model accurately portrayed the ILS elements applied to automated cartographic or photogrammetric systems employed by DMA. Results from round two of the survey indicated that 68% agreed/highly agreed that the model accurately portrayed the ILS elements applied to automated cartographic or photogrammetric systems employed by DMA (see Table 23).

For the ten ILS elements portrayed in the LSMM model, the experts were once again asked to rank most important and least important ILS elements associated with logistics support planning of automated cartographic or photogrammetric systems.

Table 23

Likert Responses
for the
Basic Characteristics of the LSMM Model
-- Round Two Delphi Survey

Topic	Ratings 1	2	3	4	5	Mean	Consensus
ILS							
Model Portrayal	0	3	5	13	4	3.72	68% agree

Legend for Ratings

5 = highly agree
4 = agree
3 = neither agree nor disagree
2 = disagree
1 = highly disagree

For round two of the survey, the experts were only required to rank the second and third most important ILS elements. Results from round one of the survey indicated that maintenance planning was ranked first with a 62% consensus agreement. In Table 24, the rank order frequencies of the second and third most important ILS elements were shown using "2" to denote the second, and "3" to denote the third most important ILS element. A weighting factor was assigned to each response to determine the second and third MOST IMPORTANT ILS elements associated with logistics support of automated cartographic or photogrammetric systems.

Table 24

Most Important ILS Elements of the LSMM Model -- Round Two Delphi Survey

ILS Elements	Rank Order Frequencies 2	3	Value or Percent Consensus
Maintenance Planning	Round One Consensus		62% agree
Manpower/Personnel	14	5	47
Design Interface	5	2	17
Training,	2	8	14
Supply Support	3	4	13
Facilities	1	1	4
Computer Resources Support	0	3	3
Technical Data	0	2	2
Support Equipment	0	0	0
Packaging, Handling, Storage and Transportation	0	0	0

A value of three was assigned to each ILS element with a "2" response; and a value of one was assigned to each ILS element with a "3" response. The total value of each ILS element determined the overall ranking, from TOP TO BOTTOM, of the MOST IMPORTANT ILS ELEMENTS (see Table 24). Although consensus was not reached for any of the elements in round two, a weighted response value of 47 strongly supports ranking manpower/personnel second. Design interface ranked

third with a weighted response value of 17 slightly ahead of training and supply support.

In Table 25, the rank order frequencies of the three least important ILS elements were shown using "8" to denote the eighth, "9" to denote the ninth, and "10" to denote the tenth least important ILS element. A weighting factor was

Table 25

Least Important ILS Elements
of the LSMM Model
-- Round Two Delphi Survey

ILS Elements	Rank Order Frequencies 10	9	8	Value or Percent Consensus
Packaging, Handling, Storage and Transportation	23	0	1	92% agree
Design Interface	1	11	4	42
Facilities	1	3	8	22
Support Equipment	0	3	7	16
Computer Resources Support	0	3	0	9
Technical Data	0	2	1	7
Manpower/Personnel	0	2	1	7
Supply Support	0	0	3	3
Training	0	1	0	3
Maintenance Planning	0	0	0	0

assigned to each response to determine the LEAST IMPORTANT ILS elements associated with logistics support planning of automated cartographic or photogrammetric systems.

A value of five was assigned to each ILS element with a "10" response; a value of three was assigned to each ILS element with a "9" response; and a value of one was assigned to each ILS element with an "8" response. The total value of each ILS element determined the overall ranking, from TOP TO BOTTOM, of the LEAST IMPORTANT ILS ELEMENTS (see Table 25). The only consensus response was packaging, handling, storage, and transportation, which was found to be the least important or ranked tenth. The experts ranked design interface ninth with a weighted value of 42 and facilities eighth with a weighted value of 22.

The experts were asked again if any of the ILS elements were not applicable to automated cartographic or photogrammetric systems and why they were not applicable. The experts' comments supported the applicability of ILS to automated cartographic or photogrammetric systems. One expert stated

> ... none - The least important call is tough, even packaging, handling, storage and transportation is important with a planning factor of 1000 failed LRU's a month, most of which must be shipped out for depot maintenance.

Another expert supported the same idea. The expert stated

> All parts of ILS are important, but unless we plan to move systems, packaging, handling, storage and transportation is probably the least important. I think some participants missed the point concerning manpower and personnel - in ILS this usually refers to

> the people maintaining the system, not the operators. Remember, this is a logistics model. There is another whole world that analyzes what the system does, how does it work, and who operates it.

Asked again if they would change any of the ILS elements or add any elements to the LSMM model, experts again responded that security is a major issue and security support should be added as a separate ILS element (see Appendix H). One expert presented a broader view of changing the ILS structure. The expert stated

> ... assigning ILS tasks to a contractor is possible, but that doesn't eliminate those requirements or abrogate our responsibility for ensuring ILS requirements are actually met.

The question concerning the extent to which DMA employed ILS in logistics support planning of automated cartographic or photogrammetric systems was asked again in round two. The experts responded on a scale from one to five, with "1" representing to no extent at all, "3" representing to a moderate extent, and "5" representing to a very great extent. Table 26 presents the response frequencies and the percent consensus agreement. Seventy-six percent of the experts agreed that DMA does employ, to a moderate extent, ILS in logistics support requirements planning of automated cartographic or photogrammetric systems (see Table 26).

Unique Factors of ILS Elements. In round one of the Delphi survey a list of factors unique to automated cartographic or photogrammetric systems was collated for each ILS element. During round two, the experts were asked

Table 26

Extent of ILS Planning
for DMA
Automated Cartographic or Photogrammetric Systems
-- Round Two Delphi Survey

Topic	Frequencies 1	2	3	4	5	Mean	Consensus
Extent of ILS Planning	0	5	19	1	0	2.84	76% agree

Legend for Frequencies

1 = No extent at all
3 = To a moderate extent
5 = To a very great extent

to review each list and provide the three most important factors, for each ILS element, that were unique to automated cartographic or photogrammetric systems. Table 27 provides a sample ranking of factors unique to automated cartographic or photogrammetric systems. Appendix K, Tables 49 through 58, lists the ranking and frequency count of each factor for the ten ILS elements in the LSMM model.

Life Cycle Determination and Design Requirements. During round two, experts again were required to complete questions concerning when in the life cycle of automated cartographic or photogrammetric systems should determination and design requirements for each ILS element take place. In round one, the experts could not reach consensus on when in the life cycle determination and design requirements for the maintenance planning, manpower/personnel, computer

Table 27

Sample Ranking of
Supply Support Factors Unique
to
Automated Cartographic or Photogrammetric Systems
-- Round Two Delphi Survey

		Frequency
1.	Adequate shelf stock of required parts	18
2.	Unique systems need unique spares, requiring long lead time	13
3.	COTS equipment has impact on the provisioning process, proprietary data rights, and basic supply support concept	10
4.	Initial spare start-up quantities	8
5.	Hardware life cycle is over before systems are in full production	7
6.	Dependent on local purchase due to unique spares not being stocked in DOD supply system	5
7.	Staging of spares	5
8.	Large computer maintenance contracts	4
9.	Steady state life cycle spare requirements	3
10.	Optical components	1
11.	Tapes, removable drives, plotter pens, plotter paper	1

resources support, facilities, and design interface elements should take place. For these five elements the experts again responded on a scale from one to five, with "1" representing the conceptual phase, "2" the advanced development phase, "3" the detailed design and development phase, "4" the production phase, and "5" the operational use phase.

Table 28 lists the ILS elements, the life cycle response frequencies, and the round two mean or consensus percent agreement.

Table 28

Life Cycle Determination and Design Requirements
for ILS Elements
-- Round Two Delphi Survey

ILS Elements	Life Cycle Response Frequencies 1	2	3	4	5	Mean or Consensus
Maintenance Planning	2	15	7	1	0	60% agree
Manpower/Personnel	0	8	16	1	0	64% agree
Computer Resources Support	1	12	11	1	0	2.48
Facilities	0	10	14	1	0	2.64
Design Interface	1	15	9	0	0	60% agree

Legend for Life Cycle Response Frequencies

1 = Conceptual phase
2 = Advanced development phase
3 = Detailed Design and Development phase
4 = Production phase
5 = Operational use phase

During round two, the experts did reach consensus on when in the life cycle determination and design requirements for the maintenance planning, manpower/personnel, and design interface elements should take place. The experts agreed maintenance planning and design interface required determination and design during the advanced development phase; and manpower/personnel required determination and design during the detailed design and development phase (see Table 28).

As in round one of the survey, the last question presented to the experts was open-ended and pertained to how well DMA applies ILS or any other logistics support planning process to automated cartographic or photogrammetric systems. One expert stated

> ... interesting perspectives, many think earlier when in reality all you get is less firmness. Best time to finalize an ILS plan is when building something.

Another expert presented an opposing viewpoint on the application of ILS for DMA automated cartographic or photogrammetric systems. The expert stated

> ... in general, life cycle costs are not addressed well in DMA. The objective of system developers is often to minimize development cost at the expense of total system life cycle costs. Because of the nature of our mission and the evolution of our systems over what is typically a very long life cycle, flexibility, adaptability, and long term maintainability should be given more consideration in the design process than have frequently been the case.

Many of the comments expressed the same idea concerning ILS and DMA automated systems. One expert summed up these comments and stated "we simply haven't done a good job here - we constantly play catch up".

Conclusion

This chapter described the results from two iterative rounds of Delphi questioning. The Delphi technique polled DMA experts in an attempt to reach consensus on the attributes and characteristics of a descriptive model required for logistics support planning of automated cartographic or photogrammetric systems. Feedback from 31

DMA experts in round one of the survey and 25 in round two provided data required to answer the three research questions proposed in Chapter I. Chapter V summarizes the findings to the research questions and develops a descriptive model to address the logistical support requirements for automated cartographic or photogrammetric systems. Chapter VI presents contributions of this research and recommendations for future research.

V. Analysis of Results

The Delphi method provided the means for constructing a descriptive model by polling expert DMA administrative, research and development, support and maintenance, and production personnel and reaching a level of consensus on logistical support planning requirements applicable to automated cartographic or photogrammetric systems.

The validity of the descriptive model was ensured by the participation of DMA experts using the iterative Delphi process. Demographic results supported the level of expertise possessed by DMA survey participants. Seventy-one percent of the participants had eight or more years experience with automated cartographic or photogrammetric systems. The experts retained a broad base of expertise as much of their experience was received in two or three DMA organizational components. The experts also demonstrated a high level of educational expertise. Seventy-four percent of the participants had a graduate degree or higher level of education.

Results from the Delphi survey concluded Ostrofsky's Logistics Systems Management Matrix (LSMM) provided the basic structure for determining logistics support procedures for automated cartographic or photogrammetric systems employed by DMA.

The results collected from two iterative rounds of Delphi questioning provided the necessary data to answer the three research questions proposed in Chapter I. The research questions will be addressed below.

Research Question One:

> Can DMA experts (administrative, research and development, production, operations support and maintenance) reach a level of consensus on the characteristics and attributes of a logistics support model applicable to automated cartographic or photogrammetric systems?

The DMA Delphi experts verified the LSMM as a descriptive model portraying the necessary logistics characteristics and attributes required to support automated cartographic or photogrammetric systems. As defined in Chapter I, the principles of management dimension portrayed in the LSMM was outside the scope of this research effort. A division of the survey, entitled the basic characteristics of the LSMM model, included three categories required to answer research question one. These sections consisted of: (1) the basic structure of the LSMM; (2) the design or life cycle processes of the model; and (3) the ILS elements portrayed in the model.

The first round of the survey provided consensus on the basic structure of the LSMM. Eighty-one percent of the experts agreed the descriptive model illustrated the necessary requirements for logistics support planning of automated cartographic or photogrammetric systems. This finding agreed with those presented in the literature review

(Chapter II). The research indicated the LSMM model forms the basis for proper implementation of a logistics support plan for any given system (Ostrofsky, 1986:8). Open-ended responses from this section (see Appendices F and H) primarily referenced terminology used in the model and not the actual structure of the model.

Although the experts unanimously agreed on the requirement for understanding design or life cycle phases, they barely reached consensus on whether the descriptive model accurately portrayed the design or life cycle phases of automated cartographic or photogrammetric systems employed by DMA. Based on the open-ended responses, the Delphi experts determined the design or life cycle terminology should have reflected specific DMA or DOD terminology (see Appendices F and H). The use of Finkelstein's design or life cycle terminology provided a common basis of understanding for all experts. The design or life cycle phases illustrated in the descriptive model accurately portrayed the entire life cycle of a system; therefore, they were found to be acceptable (Ostrofsky, 1986:7).

The experts also ranked the six design or life cycle phases in terms of importance for logistics support planning of DMA automated cartographic or photogrammetric systems. Consensus was reached on two of the design or life cycle phases. The conceptual phase ranked fifth and the retirement phase sixth. Logistics support planning of

automated cartographic or photogrammetric systems must take place early in the system life cycle (Materna and Andrews, 1988:5-4). Although the experts ranked the conceptual phase fifth, the literature supported the remaining rankings. Round one and round two results revealed identical findings. The experts ranked detailed design and development first, advanced development second, production third, and operational use fourth.

As with the design or life cycle phases, the experts highly agreed that an understanding of Integrated Logistics Support (ILS) was required for logistics support planning of automated cartographic or photogrammetric systems. Although the experts reached consensus, only 68% agreed the model accurately portrayed the ILS elements applied to automated cartographic or photogrammetric systems employed by DMA. Open-ended responses strongly recommended security support be added to the ILS dimension of the descriptive model. Security considerations are a major factor in the design of all DMA systems; therefore, this element was added to the descriptive model.

The experts ranked the ten ILS elements in terms of the three most important and the three least important for logistics support planning of automated cartographic or photogrammetric systems.

The experts reached consensus that maintenance planning ranked first. This was consistent with the findings presented in the literature review. The literature stated

maintenance planning is the first of the ten ILS elements a logistics manager must evaluate (ILS Guide, 1986:7-5). Although consensus was not reached for the remaining ILS elements in degree of greatest importance, the manpower and personnel element ranked second with a high weighted value. Responses from open-ended questions expressed a need to retain competent support personnel required to maintain automated cartographic or photogrammetric systems. Design interface, training, and supply support all ranked close to the third position with only four weighted value points separating the three elements.

In terms of least importance, the experts reached consensus and ranked packaging, handling, storage, and transportation tenth. Past experience supported this finding as DMA, with contractor support, delivered various automated systems with relatively few problems. Although consensus was not reached for the remaining ILS elements in terms of least importance, the design interface element ranked ninth with a high weighted value. Experts exhibited a poor understanding of the design interface element in their open-ended responses. This explained the inconsistent third highest and ninth lowest rankings. With new facilities already constructed for MARK 90 systems, the experts ranked the facilities element eighth.

The experts provided responses to a question concerning the extent to which DMA employed ILS in logistics support planning of automated cartographic or photogrammetric

systems. The experts reached consensus that DMA employs, to a moderate extent, ILS in logistics support requirements planning of automated cartographic or photogrammetric systems. The creation of a Directorate for Acquisition, Installation, and Logistics substantiated DMA's commitment to ILS for automated cartographic or photogrammetric systems. The literature encouraged the direction of DMA towards an ILS concept. Although automated cartographic or photogrammetric systems do not attract the attention warranted by large weapon systems, the evaluation of their ILS elements remains alike (Materna and Andrews, 1988:5-4).

Figure 15 illustrates the descriptive model developed from a review of the literature and analysis of the Delphi survey results. The model portrayed in Figure 15 was identical to the LSMM model in Figure 2 with one exception. The security element added to the ILS axis supported the feedback from experts requiring inclusion of this element in the descriptive model. Consensus agreement reached on the characteristics and attributes of the descriptive model validated the model in terms of applicability to DMA automated cartographic or photogrammetric systems.

Research Question Two:

> What factors within the ILS elements are unique and applicable to automated cartographic or photogrammetric systems?

Round one of the survey provided expert feedback on what factors, within each of the ILS elements portrayed in

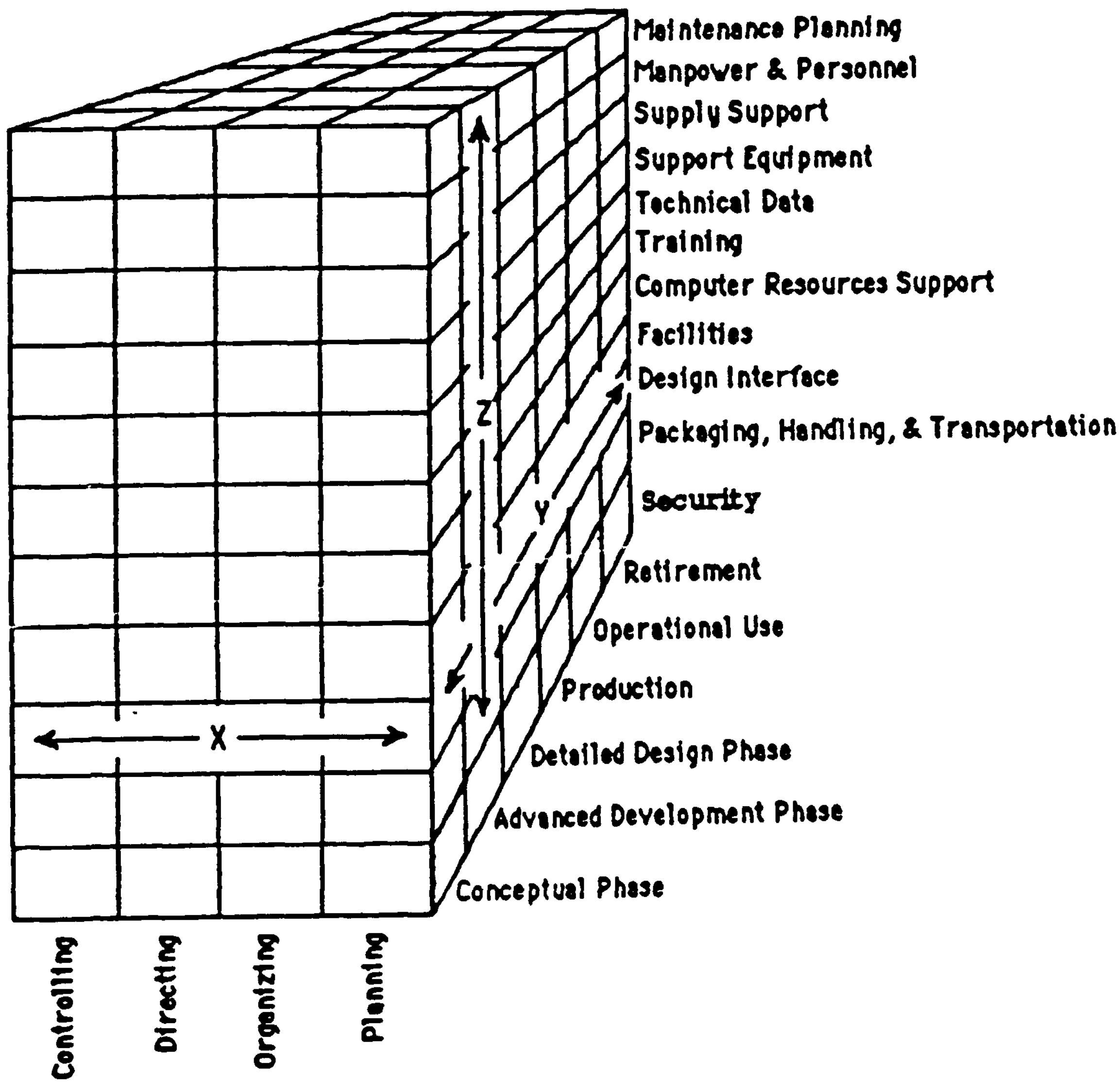


Figure 15. Descriptive Model of Logistics Support Requirements for DMA Automated Cartographic or Photogrammetric Systems

the LSMM model, were unique to logistics support planning for automated cartographic or photogrammetric systems. A list of factors unique to automated cartographic or photogrammetric systems was collated from round one responses (see Appendix J). Round two of the survey required experts to review the list and provide the three most important factors, for each ILS element, that he/she determined were unique to automated cartographic or photogrammetric systems (see Appendix K). Some experts commented that some of the factors identified were not solely unique to automated cartographic or photogrammetric systems. Nevertheless, these factors were analyzed as they applied to logistics support planning for automated cartographic or photogrammetric systems. The following analysis examines the experts' three most important responses for each ILS.

Maintenance Planning. Table 29 illustrates the three most important maintenance planning factors unique to automated cartographic or photogrammetric systems.

The determination of whether the maintenance support will be in-house or contract allows managers to plan for the development of all other logistics support elements (ILS Guide, 1986:7-5). Planning requirements for manpower and personnel staffing levels, supply support inventory levels, and procurement of support equipment are determined based on whether the maintenance will be in-house or contract.

Table 29

Three Most Important Maintenance Planning Factors
Unique to
Automated Cartographic or Photogrammetric Systems

1. Determine whether maintenance support will be in-house or contract

2. Corrective hardware/software maintenance

3. Maintenance planning should be a continuous process throughout the life cycle systems

Corrective maintenance involves the actions performed, as a result of failure, to restore a system to an operational condition (ILS Guide, 1986:A-1). Adequate corrective maintenance procedures ensured availability of automated cartographic or photogrammetric systems to meet production requirements for DMA earth data products.

Maintenance planning required continuous updating throughout the life cycles of automated cartographic or photogrammetric systems. The maintenance plan developed in the detailed design and development phase identifies required levels of maintenance, equipment, and the intervals needed to support a system (ILS Guide, 1986:7-5). The maintenance plan is one example of a maintenance document which requires updating throughout the life cycle of a system.

Manpower and Personnel. Table 30 illustrates the three most important manpower and personnel factors unique to automated cartographic or photogrammetric systems.

Table 30

Three Most Important Manpower and Personnel Factors Unique to Automated Cartographic or Photogrammetric Systems

1. Ability to retain competent personnel
2. Limited skilled personnel to maintain hardware and software
3. Systems need to be designed and maintained to meet requirements of production manpower and personnel

The problem of retaining competent and skilled personnel required to maintain automated cartographic or photogrammetric systems is a high priority for DMA. Appropriate skill levels and quantities of maintenance personnel must be attained to ensure the required support of systems (Finkelstein and Guertin, 1988:114). Flexible work schedules, pay adjustments, and fringe benefit incentives are avenues DMA and the government pursue to hire and retain skilled maintenance personnel. Design of these systems permitted simple preventive maintenance tasks to be performed by the operator of the system. Daily maintenance tasks performed by the operators of these systems minimize extended down times associated with dust and dirt build up.

Supply Support. Table 31 illustrates the three most important supply support factors unique to automated cartographic or photogrammetric systems.

Table 31

Three Most Important Supply Support Factors
Unique to
Automated Cartographic or Photogrammetric Systems

1. Adequate shelf stock of required parts
2. Unique systems need unique spares, requiring long lead time
3. Commercial Off-The-Shelf (COTS) equipment has impact on the provisioning process, proprietary data rights, and basic supply support concept

Maintaining adequate levels of spare parts ensured the availability of automated cartographic or photogrammetric systems to meet DMA mission requirements. Special components, such as Integrated Circuit Boards (ICB) and optics, required long lead times for repairs. Levels of shelf stock for these components must be maintained to minimize down time.

DMA automated systems, as well as many other government systems, contain COTS components. COTS components for DMA automated cartographic or photogrammetric systems are procured directly through the COTS vendor rather than through the system contractor. Interrelationships between acquisition and logistics personnel guaranteed procedures

were in place to address potential problems associated with COTS equipment.

Support Equipment. Table 32 illustrates the three most important support equipment factors unique to automated cartographic or photogrammetric systems.

Table 32

Three Most Important Support Equipment Factors
Unique to
Automated Cartographic or Photogrammetric Systems

1. Calibration of support and test equipment
2. Design for easily replaced logical units, which are easily repaired
3. Calibration of photogrammetric equipment is critical

The experts' comments focused on the calibration of unique support equipment. Precise cartographic or photogrammetric specifications required calibrated support and test equipment be maintained on-site at the production centers. Calibration of the support and test equipment was performed by contractors through an inter-service support agreement.

Technical Data. Table 33 illustrates the three most important technical data factors unique to automated cartographic or photogrammetric systems.

Technical data allowed maintenance personnel to perform corrective maintenance such as fault isolation and

Table 33

Three Most Important Technical Data Factors
Unique to
Automated Cartographic or Photogrammetric Systems

1. Maintenance and diagnostics documentation
2. Software documentation and interface manuals
3. Communicate with contractor when developing manuals used for production and maintenance

troubleshooting. Hardware and software maintenance documentation developed by the systems' contractors were provided to DMA at time of delivery. DMA personnel assisted in the design and development of these documents during the advanced development phase (Finkelstein and Guertin, 1988:136). Formal review of the documents upon delivery to DMA assured compliance with requirements set forth early in the life cycle.

Training. Table 34 illustrates the three most important training factors unique to automated cartographic or photogrammetric systems.

The training for DMA automated cartographic or photogrammetric systems included both in-house and contractor conducted courses. Before training commenced, training documents were reviewed to correct discrepancies. Cadre training conducted by systems' contractors provided DMA with in-house personnel who could assist with preparatory training. Preparatory training furnished

Table 34

Three Most Important Training Factors
Unique to
Automated Cartographic or Photogrammetric Systems

1. Critical/preliminary design review of training plans
2. In house hardware/software training must be in depth
3. Need preparatory training

employees with fundamental skills required for detailed management, maintenance, and operations training for automated cartographic or photogrammetric systems. Once systems were operational, additional in-house training provided new employees with the skills required to support DMA systems.

Computer Resources Support. Table 35 illustrates the three most important computer resources support factors unique to automated cartographic or photogrammetric systems.

The computer resources support element pertained to the hardware and software resources required to maintain the automated cartographic or photogrammetric systems. Growing concern from DMA experts centered on diagnostic software required to trace hardware deficiencies and fault isolation to a line replaceable unit. Lessons learned from MARK 85 demonstrated a need to maintain a separate facility to test upgrades to software codes without impacting operational systems and delaying production schedules.

Table 35

Three Most Important Computer Resources Support Factors Unique to Automated Cartographic or Photogrammetric Systems

1. Diagnostic software
2. Flexibility, expandability, peak capacity, and fault isolation to Line Replaceable Unit (LRU)
3. Need a development test facility to test software code fixes and upgrades instead of tying up production equipment

Facilities. Table 36 illustrates the three most important facilities factors unique to automated cartographic or photogrammetric systems.

Table 36

Three Most Important Facilities Factors Unique to Automated Cartographic or Photogrammetric Systems

1. Designed for human occupation not just machines
2. Clean environment
3. Space requirements

Unlike many automated systems, DMA automated cartographic or photogrammetric systems required a human interface for the entire period of operation. Design engineering and logistics support requirements must take into account ergonomic considerations. As with any

automated system, DMA systems are operated in a clean environment to minimize the risk associated with dust and dirt. Space requirements were a concern although the construction of new facilities at the DMA Reston Center and DMA Hydrographic/Topographic Center alleviated some space problems.

Packaging, Handling, Storage, and Transportation. Table 37 illustrates the three most important packaging, handling, storage, and transportation factors unique to automated cartographic or photogrammetric systems.

Table 37

Three Most Important
Packaging, Handling, Storage, and Transportation Factors
Unique to
Automated Cartographic or Photogrammetric Systems

1. Security of classified items
2. Equipment size and weight
3. Shipment of component items from repair depot to customer

Security procedures are always the first consideration for all DMA activities. Security control methods for documents, software, equipment and components must be considered early in the packaging, handling, storage, and transportation phase of the system life cycle. The size and weight of automated cartographic or photogrammetric systems required planning to allow for restricted passageways,

elevators, raised-floor load capacities, and handling equipment.

Design Interface. Table 38 illustrates the three most important design interface factors unique to automated cartographic or photogrammetric systems.

Table 38

Three Most Important Design Interface Factors
Unique to
Automated Cartographic or Photogrammetric Systems

1.	Function of overall system design
2.	Reliability/Maintainability requirements
3.	Need to incorporate this element early in the life cycle

System readiness objectives and logistics constraints associated with design interface are established early in the systems life cycle. The major functions of design interface were reliability and maintainability as defined by the DMA experts. Reliability designed early in the life cycle of a system adds to the supportability of the system. Maintainability applied early in the life cycle prevents high maintenance costs during system operations.

These unique factors of ILS elements provided guidance for identifying logistics support planning requirements applicable to automated cartographic or photogrammetric systems.

Research Question Three:

> At what stages of the automated system's life cycle do the ILS elements require determination and design?

The Delphi survey required experts to complete questions concerning when in the life cycle of automated cartographic or photogrammetric systems should determination and design requirements for each ILS element take place. The Delphi experts reached consensus on eight of the ten ILS elements. The two ILS elements for which consensus was not reached were computer resources support and facilities. Using the mean values depicted in Table 28, page 91, determination and design requirements for computer resources support should take place during the advanced development phase, and facilities during the detailed design and development stage. Figure 16 illustrates at what phase of the automated cartographic or photogrammetric systems life cycle ILS requirements determination and design take place. Delphi results indicated maintenance planning, computer resources support, and design interface determination and design requirements take place during the advanced development stage. Manpower and personnel, supply support, support equipment, technical data, training, facilities, and packaging, handling, storage, and transportation determination and design requirements take place during the detailed design and development stage. In the following section, the Delphi responses are analyzed with respect to the findings of the literature review.

	Conceptual Phase	Advanced Development Phase	Detailed Design Development Phase	Production Phase	Operational Use Phase	Retirement Phase
Maintenance Planning		X				
Manpower and Personnel			X			
Supply Support			X			
Support Equipment			X			
Technical Data			X			
Training			X			
Computer Resources Support		X				
Facilities			X			
Packaging, Handling, Storage, and Transportation			X			
Design Interface		X				

Figure 16. Life Cycle Determination and Design Requirements for ILS Elements

Maintenance Planning. The Delphi responses for maintenance planning agreed with those presented in the literature review. Although the literature indicated the maintenance concept is developed during the conceptual phase, the specific maintenance tasks and operational requirements are not identified until the advanced development phase. Furthermore, the detailed maintenance plan is not created until the end of the detailed design and development phase or early in the production phase (Finkelstein and Guertin, 1988:110). Delphi results indicated maintenance planning determination and design requirements occur during the advanced development phase. This allowed adequate time for the development of maintenance requirements for automated cartographic or photogrammetric systems.

Manpower and Personnel. The literature discussed the need to first estimate manpower and personnel criteria during the conceptual phase. Precise manpower and personnel requirements were formulated in accordance with the Delphi results. Both the literature review and the Delphi results indicated specific manpower and personnel determination and design requirements occur during the detailed design and development phase of automated cartographic or photogrammetric systems. Updates to manpower and personnel are made according to production requirements throughout the remaining life cycle.

Supply Support. According to the literature, supply support is initiated during the advanced development phase. The Delphi results indicated supply support determination and design requirements occur during the detailed design and development phase. Although provisioning occurs during the detailed design and development phase, planning for parts obsolescence must take place during the advanced development phase.

Support Equipment. The literature indicated the support equipment element must be planned and developed during the conceptual phase. The decision whether to purchase new support equipment or use existing equipment must take place early in the system life cycle. The Delphi responses agreed with specific support equipment considerations presented in the literature.

> During the detailed design and development phase, detailed task analyses and documentation are performed to identify the specific equipment requirements for every operating and maintenance task. (ILS Guide, 1986:7-9).

Technical Data. The literature disagreed with the Delphi results for the technical data element. The literature stated that technical data requirements take place in the advanced development phase and the Delphi results indicated the detailed design and development phase. Both technical data, relating to operations and maintenance, and management data, must be developed during the advanced development phase (Finkelstein and Guertin, 1988:136). Preliminary technical data manuals must be accessible late

in the advanced development phase to support testing and training functions (ILS Guide, 1986:7-10). These findings supported the need to determine and design technical data requirements in the advanced development phase.

<u>Training</u>. The Delphi results for the training element agreed with the literature review. The Delphi results and the literature review indicated requirements for training determination and design during the detailed design and development phase.

> Although DODD 5000.39 specifies that detailed descriptions of current and projected skill and training resources be developed during the conceptual phase, specific requirements for training and equipment are performed during advanced development and detailed design and development phases. (ILS Guide, 1986:7-10)

<u>Computer Resources Support</u>. The Delphi results supported the requirement for determination and design of computer resources support during the advanced development stage. The literature review presented the same findings. During the conceptual phase and the advanced development phase system concepts are developed and the system/hardware and system/software requirements are defined and examined (Tile, 1987:238).

<u>Facilities</u>. Consensus was not reached for this element during the Delphi survey. Although the mean value indicated the selection was detailed design and development, 40% of the experts chose the advanced development phase. The literature indicated the facilities planning requirements function takes place during the advanced development phase.

Ninety-six percent of the Delphi experts selected either the advanced development or detailed design and development phase. The results tended to support the findings of the literature review.

Packaging, Handling, Storage, and Transportation. The literature review and Delphi results disagreed with respect to determination and design requirements for packaging, handling, storage, and transportation. The literature review supported the advanced development phase, while the Delphi results advocated the detailed design and development phase. During the advanced development phase, the literature indicated that specific transportation attributes are identified, and packaging and handling requirements are evaluated and determined (ILS Guide, 1986:7-11). The findings supported the advanced development phase for requirements determination and design of the packaging, handling, storage, and transportation element.

Design Interface. The literature review and the Delphi results agreed on determination and design requirements for the design interface element. The two major functions of design interface, reliability and maintainability, must be determined and designed in the advanced development phase. Early life cycle design of these functions ensures supportability and prevents high maintenance costs throughout the entire system life cycle (Finkelstein and Guertin, 1988:72).

Conclusion

This chapter analyzed the Delphi results found in Chapter IV. Where possible, the results of the Delphi survey were compared against those findings presented in the literature review found in Chapter II. A descriptive model was developed based on the results of the Delphi survey of 31 DMA experts. A list of the three most important factors, for each ILS element, unique to automated cartographic or photogrammetric systems was collated from the Delphi results. Finally, results from the Delphi survey were compared with the literature to determine when in the life cycle of automated cartographic or photogrammetric systems determination and design requirements for each ILS element should take place. The answers to the research questions found in this chapter provided the framework required to identify logistics support planning requirements for automated cartographic or photogrammetric systems. Chapter VI presents the contributions of this research and recommendations for future research.

VI. Conclusions and Recommendations

Today's high-technology military weapon systems require precise digital mapping, charting, and geodetic data. To respond to these digital-based earth data requirements, DMA initiated a massive program to convert from a manual to an all digital production capability by 1993. Requirements for accurate and timely digital-based earth data products necessitated proper logistics support planning for automated cartographic or photogrammetric production systems.

Although DMA lacked an integrated approach of formulating logistical support planning requirements for their automated cartographic or photogrammetric systems, management recognized the importance of the Integrated Logistics Support (ILS) concept. Both the creation of a new Directorate for Acquisition, Installation, and Logistics and the sponsorship of this research support the premise that DMA has identified the need for logistics support planning of automated cartographic or photogrammetric systems.

This research was initiated to determine how an Integrated Logistics Support (ILS) or other logistical support planning model can provide a means for determining logistical support requirements for DMA automated systems. The literature review identified Ostrofsky's Logistics Systems Management Matrix (LSMM) as the basis for proper implementation of a logistics support plan for any given

system (Ostrofsky, 1986:8). The LSMM model was used as the foundation for the development of a descriptive model applicable to logistics support planning of automated cartographic or photogrammetric systems.

The Delphi method provided the means for constructing a model by polling expert DMA administrative, research and development, support and maintenance, and production personnel. The intent of this methodology was to reach a level of consensus on characteristics and attributes of a model applicable to automated cartographic or photogrammetric systems. The validity of the model constructed was ensured by the participation of DMA experts using the iterative Delphi process. The survey results concluded DMA experts agreed that the LSMM model provided the basic structure for determining logistics support procedures for automated cartographic or photogrammetric systems employed by DMA. The experts provided feedback on what factors, within each of the ILS elements portrayed in the LSMM model, were unique to logistics support planning for automated cartographic or photogrammetric systems. Finally, the experts decided at what phase of the automated cartographic or photogrammetric system life cycle the ILS elements required determination and design.

Discussion

This research was initiated to determine how a logistics support model can provide a framework for

determining logistical support requirements for DMA automated cartographic or photogrammetric systems. The research objectives to accomplish this were: (1) to develop a descriptive model to address the logistical support requirements for automated cartographic or photogrammetric systems; and (2) validate the model by determining its relevance to DMA automated cartographic or photogrammetric systems.

The descriptive model is a very general guide to determining logistics support requirements for automated cartographic or photogrammetric systems. The model provided the basic principles of management, the design or life cycle of systems, and the ILS elements required to support automated cartographic or photogrammetric systems. Another characteristic of the descriptive model is its similarity to the Logistics Systems Management Matrix (LSMM). The addition of the ILS security element is the only difference between the models. This is not unusual as the LSMM forms the basis for proper implementation of a logistics support plan for any given system. The modifications to Ostrofsky's original LSMM provided a common basis of understanding for the Delphi experts.

The descriptive model developed was validated by using the iterative Delphi process. The survey process determined if DMA management believed the characteristics and attributes of the model were valid for DMA's high-

technology, fast-obsolescence systems. Feedback from the experts confirmed the validity of the descriptive model.

Conclusions

Although descriptive in nature, this research provided the framework required to identify logistics support planning requirements for automated cartographic or photogrammetric systems. The following six conclusions summarize the findings of this research.

1. The need existed for a structured, integrated logistics support approach to automated cartographic or photogrammetric systems planning. Results from the Delphi survey revealed DMA only employs ILS concepts to a moderate extent. Nevertheless, DMA experts recognized the importance of ILS for automated cartographic or photogrammetric systems planning. The experts reached a level of consensus (94% agreement) that understanding and applying ILS concepts was important for logistics support planning of automated cartographic or photogrammetric systems.

2. Beyond an ILS approach, the need existed for an integrated organizational structure permitting the execution of an ILS plan. The functional differences of DMA experts prevented consensus for several items in the Delphi survey. The experts were unable to reach consensus for the ranking of design or life cycle phases and ILS elements. The findings in this research supported the findings of the DOD and DMA Inspector Generals.

In the past, logistics functions were performed in a variety of DMA components. The DOD Inspector General (IG) Report of 1989 recommended the consolidation of DMA logistics functions into a single unified directorate (DOD IG Report INS 89-02A, 1989:47). The DMA IG supported the DOD IG findings and stated

> ... the DMA IG recommends the consolidation of all logistics and logistics-related functions as a Deputate for logistics and engineering to include directorates for logistics plans, maintenance, transportation, supply and distribution, procurement, and facilities. (DMA IG Report, DMASC Inspection Report, 1989:III-1)

This high-level integrated approach to logistics is not unique to DMA or DOD and is evident in competitive commercial firms.

> In successful firms logistics has been elevated to a top management position, often of equal ranking with marketing (requirements) and production. One study found that of 47 companies having a physical distribution (logistics) manager, in 37 (79 percent) of the companies he/she was either a vice president or reported to a vice president. (Ballou, 1973:8)

3. The need existed to determine and design logistics support requirements early in the system life cycle of automated cartographic or photogrammetric systems. The Delphi results indicated maintenance planning, computer resources support, and design interface determination and design requirements take place during the advanced development stage, while manpower and personnel, supply support, support equipment, technical data, training, facilities, and packaging, handling, storage, and transportation determination and design requirements take

place during the detailed design and development stage. These findings agreed with the results of ranking the design or life cycle phases. The experts ranked detailed design and development phase first and advanced development phase second.

4. Maintenance planning was most vital to the ILS planning effort of automated cartographic or photogrammetric systems. Both the literature and the Delphi results supported this finding. Maintenance planning is both the first of ten elements a logistics manager must evaluate and "the process to develop maintenance concepts and maintenance requirements of the system" (ILS Guide, 1986:7-5). The experts also reached consensus and ranked maintenance planning first, out of the ten ILS elements, in terms of importance for logistics support planning of automated cartographic or photogrammetric systems.

5. While important, packaging, handling, storage, and transportation (PHS&T) was least vital to the ILS planning effort of automated cartographic or photogrammetric systems. The experts reached consensus and ranked (PHS&T) tenth, out of the ten ILS elements, in terms of importance for logistics support planning of automated cartographic or photogrammetric systems. This was attributable in part to the absence of delivery problems in the recent deployment of various automated systems. Also, some experts provided open-ended comments which described automated cartographic or photogrammetric systems as relatively static. Because

these systems were moved infrequently, packaging, handling, storage, and transportation was considered the least important ILS element.

6. DMA logistics personnel without cartographic or photogrammetric backgrounds should use the identified unique factors within each ILS element to gain insight to the special logistics requirements of automated cartographic or photogrammetric systems. Particular areas requiring attention were: (1) design and maintenance requirements to meet ergonomic needs of cartographic or photogrammetric production personnel; (2) calibration requirements of photogrammetric equipment; (3) development a test facility to verify software code fixes and upgrades instead of tying up production systems; and (4) meet security requirements for all logistics support items.

Recommendations

The following four recommendations for future research and use of the descriptive model are suggested.

1. Future research based on the descriptive model developed in this thesis should utilize DOD life cycle terminology. At the time this research was conducted, DOD life cycle terminology was under revision. Rather than introduce confusion brought about by changing DOD terminology, Finkelstein and Guertin's life cycle terminology was used. This terminology provided a basis for common understanding of life cycle phases.

2. Research should be conducted to examine the principles of management as they apply to the other two dimensions of the descriptive model. The limited treatment of the principles of management in this research was a function of the time constraint inherent to the thesis effort.

3. DMA management should consider employing the findings of this research because it was intended to be used by managers for generalized logistics support requirements planning of automated cartographic or photogrammetric systems. The descriptive model should become part of initial DMA logistics support planning activities for automated cartographic or photogrammetric systems. The descriptive model will provide DMA logistics managers, as well as other functional managers, with guideline criteria for developing specific logistics support requirements for automated cartographic or photogrammetric systems. It will ensure the integration of management principles and ILS elements throughout the entire life cycle of automated cartographic or photogrammetric systems.

4. In addition to automated cartographic or photogrammetric systems, DMA utilizes various automated management information and photographic systems. The need exists for exploratory ILS research for these automated systems. The findings of this research provide a basis for logistics support applications on any automated systems employed in or outside of DMA.

Contributions

The four contributions of this research are: (1) the descriptive model; (2) the unique factors, within each ILS element, applicable to automated cartographic or photogrammetric systems; (3) life cycle determination and design requirements for each ILS element; and (4) the comments provided by the DMA Delphi experts.

Descriptive Model. The descriptive model developed in this research effort provides DMA managers a logistics support planning tool applicable to automated cartographic or photogrammetric systems. The model represents a combined feedback effort from various functional DMA experts. These experts possess a wealth of knowledge and experience concerning automated cartographic or photogrammetric systems. The Delphi method provided the means required to capture the opinions of these experts and formulate the findings into a descriptive model. The experts' interest in the subject is reflected by the amount of opinion data provided in the two rounds of questioning.

The DMA experts reached consensus on the dimensions of the descriptive model because the model accurately portrayed the characteristics and attributes required for logistics support planning of automated cartographic or photogrammetric systems. The model incorporated the management principles, design or life cycle phases, and ILS elements required to support DMA automated cartographic or photogrammetric systems. Although the Delphi respondents

possessed diverse functional expertise within DMA, their ability to understand and reach consensus on the dimensions of the descriptive model verified the future use of the model for DMA automated cartographic or photogrammetric systems.

Total consensus was not reached for the ranking of design or life cycle phases and ILS elements. Non-consensus for certain design or life cycle phases resulted from functional bias of the experts. Production experts believed the operational use phase was most important while research and development and support and maintenance experts concluded the advanced development phase was most important.

Non-consensus and inconsistencies for the ILS elements resulted from the lack of total understanding of ILS element definitions. Although detailed definitions were provided to the experts in both rounds of Delphi questioning, the feedback from the experts presented a lack of experience in applying ILS concepts.

Unique Factors Within ILS Elements. The lists of unique factors, within each ILS element, applicable to automated cartographic or photogrammetric systems provided a general reference for planning, designing, and developing logistics support procedures for automated cartographic or photogrammetric systems.

The Delphi responses provided by the DMA experts represent professional opinions from some of the foremost minds in cartography or photogrammetry. Many logistics

managers employed by DMA do not possess cartographic or photogrammetric skills or education. The lists of unique factors, within each ILS element, applicable to automated cartographic or photogrammetric systems provide the beginnings of an expert system for logistics managers not possessing cartographic or photogrammetric skills. These lists are also a valuable tool for other governmental agencies employing automated cartographic or photogrammetric systems. Finally, some of the factors are generic in nature and can be applied to other automated management information systems.

Life Cycle Determination and Design Requirements. The life cycle determination and design requirements for each ILS element provide managers an excellent tool for logistics support planning purposes. These findings represent generalized descriptions of specifically outlined logistics support determination and design tasks found in DODD 5000.39.

The Delphi results agreed with the literature review for determination and design requirements of automated cartographic or photogrammetric systems. The experts agreed all determination and design requirements for ILS elements should take place early in the system life cycle. These findings impact the logistics support planning requirements for the entire life cycle of automated cartographic or photogrammetric systems. The design, development, and implementation of automated cartographic or photogrammetric

systems involve interrelationships of the four functional groups which participated in the Delphi survey. Agreement by the four functional groups on the need for early determination and design of ILS elements will allow DMA to design supportability into automated cartographic or photogrammetric systems. In turn, early determination and design will lower operations and maintenance costs and provide increased levels of mission readiness.

Delphi Experts' Comments. The final contribution of this research is the opinion data provided by DMA experts. The experts reached consensus and determined DMA employs ILS to its automated cartographic or photogrammetric systems only to a moderate extent. The experts' comments further suggest a need for an Integrated Logistics Support approach for DMA automated cartographic or photogrammetric systems.

The creation of a Directorate for Acquisition, Installation, and Logistics must integrate the fragmented logistics support policies and procedures in place at DMA. To minimize the support and maintenance costs associated with operational systems, logistics support requirements must be designed and developed early in the life cycle of automated cartographic or photogrammetric systems.

Summary

Government agencies and military services require accurate and timely earth data (mapping, charting, and geodetic data) to support mission objectives. The Defense

Mapping Agency is responsible for providing earth data in digital and graphic formats through the use of automated cartographic or photogrammetric systems. It is imperative that DMA adapt an Integrated Logistics Support (ILS) approach to properly support and maintain these automated systems.

This research provided a thorough description of logistics support planning for DMA automated cartographic or photogrammetric systems. Its analysis demonstrated the need for an integrated structured approach to logistics support, an integrated organizational structure to implement ILS plans, and an increased emphasis on maintenance planning to more effectively support automated cartographic or photogrammetric systems.

Appendix A: Weapons Systems Requiring DMA Earth Data

Joint Service Systems

AGM-86 Air Launched Cruise Missile (ALCM)
AGM-129 Advanced Cruise Missile (ACM)
Cruise Missile Advanced Guidance (CMAG)
DARPA Image Generation (Side VU)
Joint Automated Terminal Instrument Procedures (AUTO TERPS)
Joint Surveillance Target Attack Radar System
Navstar Global Positioning System (GPS)
Precision Location Strike System (PLSS)
Satellite (Overland) Altimetry
Tactical Reconnaissance Exploitation Demonstration System (TREDS)/TR-1 Ground Station (TRIGS)
Terminal Fix Sensor (TFS)
TR-1 Reconnaissance System
Tomahawk BGM-109A/B/C/D Cruise Missile

Air Force Systems

Advanced Computer Flight Plan (USAFACFF)
Advanced Technology Bomber
AF Rescue Coordination Center Planning System (AFRCCPS)
Automated Combat Mission Folder System (ACMFS)
B-1B
B-52 Weapon System Trainer (WST)
C-17
C-130 Weapon System Trainer (WST)
Computer Aided Mission Planning System (CAMPS)
EF-11A Operational Flight Trainer (OFT) System
EF/F/FB-111 Weapon System Trainer (WST)
Enemy Situation Correlation Element (ENSCE)
F-15E Weapons System Trainer (WST)
F-16 Digital Radar Landmass Simulator (DRLMS)
F-16 Improved Digital Radar Landmass Simulator (IDRLMS)
Filmstrips
Integrated Terrain Access and Retrieval System (ITARS)
Minuteman
National Aerospace Plane (NASP)
On Board Electronic Warfare Simulator (OBEWS)
Pave Pillar
PEACEKEEPER
Remote Map Readers (RMR)
Small Intercontinental Ballistic Missile (SICBM)
Survivable Strategic Missile Launcher
Tactical Air Forces (TAF) Small Computer Project
Tactical Re-entry Impacting Munitions (TRIM)

Army Systems

All Source Analysis System (ASAS)
All Source Exploitation In A Combat Environment
Army Training Battlefield Simulation System (ARTBASS)
Battlefield Management System (BMS)
Digital Topographic Support System (DTSS)
Fiber Optics Guided Missile (FOG-M)
Firefinder: AN/TPQ-36 and AN/TPQ-37 Mortar and Artillery Locating Radar
Maneuver Control System (MCS)
Night Navigational and Pilotage System (NNAPS)
PATRIOT Surface to Air Missile System
Pershing II
Position Locating Reporting System (PLRS)
Remotely Monitored Battlefield Sensor (REMBASS)
Remotely Piloted Vehicle (RPV-AQUILA)
Vehicle Integrated Intelligence V(INT)<
Vehicle Navigation Aid System (VNAS)

Navy Systems

A-6E Weapon System Trainer (WST)
AEGIS Air Defense System
AN/BSY-1, FY89 Combat System (formerly SUBACS)
AN/WLQ-4, Sea Nymph
AV-8B Support
Carrier Battle Group (CVBG) Special Chart
E-2C Weapon System Trainer (WST)
EA-6B Weapon System Trainer (WST)
Encapsulated Torpedo (CAPTOR) Mine
Navy Command and Control System
Navy Optimum Path Aircraft Routing System (OPARS)
Over-the-Horizon-Targeting (OTH-T) Tomahawk and Harpoon Systems
Trident and Trident II

Source. (Larson and Pelletiere, 1989:103-05)

Appendix B: MARK 85 SYSTEM

General Information

MARK 85: The first phase of the Digital Production System (DPS), it was a transitional step which upgraded DMA's production system and provided initial digital exploitation capability. MARK 85 has been delivered and is in use at DMA production centers (DOD/DMA DPS Handbook, 1989:i). There are 6 segments of the MARK 85 production system. The following are descriptions of these segments.

MARK 85 Segments

DIGITAL COMPARATOR (DC/S): DC/S provides the capabilities to measure tie points and extract elevation data from softcopy imagery.

DATA INTEGRATION (DI/S): DI/S provides program management, production management, source collection and acquisition management, and management of various non-imagery source libraries and data bases.

FEATURE EXTRACTION (FE/S): FE/S provides capabilities to perform feature extraction from hardcopy imagery and produces Digital Feature Analysis Data (DFAD), Digital Terrain Analysis Data (DTAD), Vertical Obstruction Data (VOD), and elevation extraction and maps/charts data.

HARDCOPY EXPLOITATION (HE/S): HE/S provides the capabilities to exploit hardcopy imagery for mensuration, triangulation, terrain elevation extraction, point target coordinate derivation, rectification, orthorectification, and Deployable Point Positioning Data Base (PPDB) cartridge generation.

SOURCE ACQUISITION (SA/S): SA/S provides tasking for imagery collection, imagery assessment, production feasibility analysis, and image library management.

UNIVERSAL RECTIFIER (UR/S): UR/S provides the capabilities to rectify softcopy imagery and generate PPDB film chips.

Appendix C: MARK 90 SYSTEM

General Information

MARK 90: The second phase of the Digital Production System (DPS), it provides an all-digital softcopy production system which will improve production efficiencies and accommodate mandatory conversion to exploitation of improved source materials. In March 1991, the MARK 90 system will reach its Initial Operating Capability (IOC). Full Operating Capability (FOC) will occur in March 1992 for all 31 products in the DPS baseline (DOD/DMA DPS Handbook, 1989:ii). The MARK 90 system will consist of five MARK 90 segments and the residual of two MARK 85 segments. The following is a brief description of these segments.

MARK 90 Segments

DATA EXTRACTION (DE/S): DE/S provides the capabilities to extract terrain elevation and feature data from softcopy imagery, attribute extracted features, edit and merge new to existing extracted data, and perform quality checks to ensure extracted data is in compliance with extraction specifications.

DATA SERVICES (DS/S): DS/S is comprised of two components, a data base/data management subsystem and a communications subsystem. The data base/data management subsystem provides capabilities to archive and provide access to MARK 90 MC&G data and to protect its integrity. The communications subsystem of DS/S provides all narrowband communications for each segment's internal communications for intersegment communications within a center, and for intercomponent communications via the Integrated DMA Telecommunications System (DITS) within a center. It also provides wideband communications for imagery to the production segments. The communications wideband service provides the

capabilities to read compressed softcopy imagery from Magnetic Tape Cassettes (MTCs) and provide it to the MARK 90 production elements (SP/S, DE/S, PG/S) within a production center.

PRODUCT GENERATION (PG/S): PG/S provides the capability to extract and attribute feature data from monoscopic imagery and cartographic sources, to extract air facilities and flight information data, to evaluate and process bathymetric data, to edit and merge existing to extracted data, to compile MARK 90 data into hardcopy reproducible masters or digital products, and to perform quality checks to ensure production is in compliance with product specifications.

PRODUCT MANAGEMENT (PM/S): PM/S provides a single integrated production management capability for all of DMA. The segment provides the capability to perform Agency level programming and planning; to schedule, manage and monitor production center resources and production assignments and to monitor and report production progress. The PM/S also accounts for customer requirements.

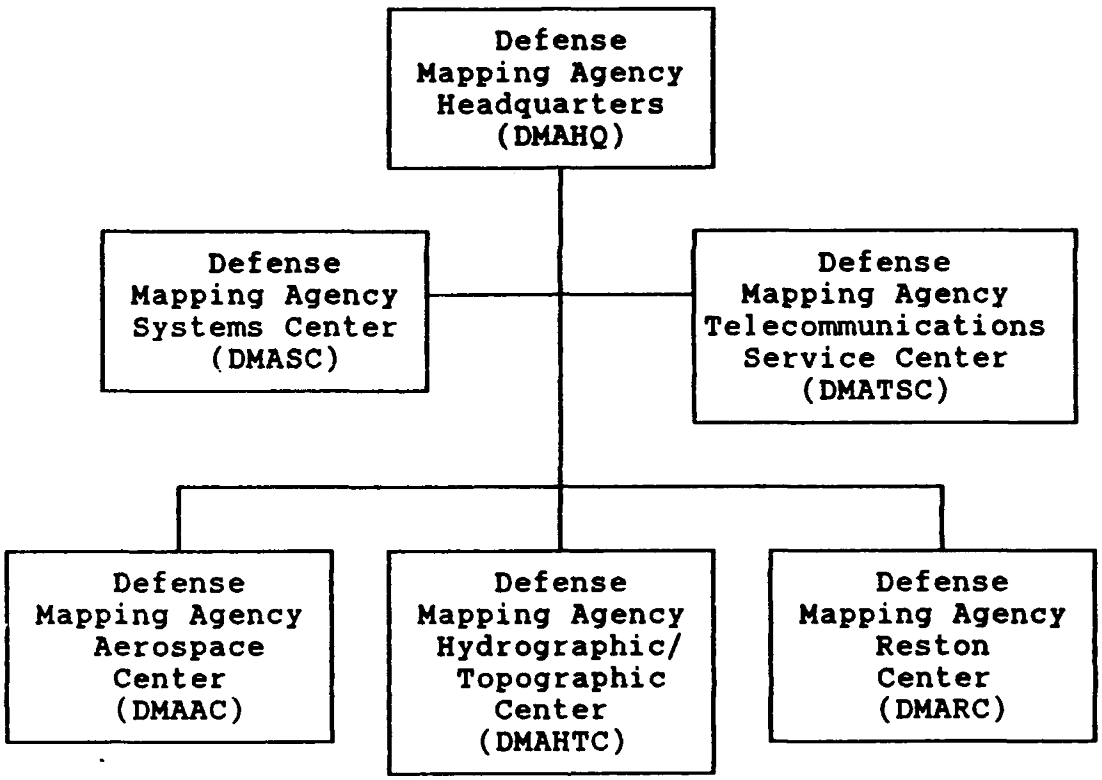
SOURCE PREPARATION (SP/S): SP/S provides the capabilities to review and evaluate multi-media source materials, measure softcopy imagery to support triangulation, produce point target products, and generate Source Use Packages (SUP) for use by production.

MARK 85 Residual Segments

HARDCOPY EXPLOITATION (HE/S): HE/S provides the capabilities to exploit hardcopy imagery for mensuration, triangulation, terrain elevation extraction, point target coordinate derivation, rectification, orthorectification, and Deployable Point Positioning Data Base (PPDB) cartridge generation.

SOURCE ACQUISITION (SA/S): SA/S provides tasking for imagery collection, imagery assessment, production feasibility analysis, and image library management.

Appendix D: DMA Organizational Structure



DMA Headquarters (DMAHQ) provides high-level policy guidance and oversight to all components concerning administrative, research and development, support and maintenance, and production. The Transition Management Office (TM) assists the Director of DMA in formulation of DMA policies, long-term objectives, implementation strategies, and plans to assure an effective transition, both managerially and technically, to an all digital production system. Research and Engineering (RE) serves as the staff proponent for DMA and all its functions.

DMA Systems Center (DMASC) is responsible for the requirements definition, design, development, procurement, installation, transition, and maintenance of the Digital Production System as well as all other R&D activities, production line maintenance, and configuration management.

DMA Telecommunications Services Center (DMATSC) is responsible for overall coordination of telecommunications activities across DMA, operations and maintenance of the Integrated DMA Telecommunication System (IDTS), and security accreditation and communication maintenance.

The three DMA production centers, DMA Reston Center (DMARC), DMA Aerospace Center (DMAAC), and DMA Hydrographic Topographic Center (DMAHTC), support the Digital Production System development and transition activities primarily through two organizations:

(1) Research and Engineering Directorate (RE) which oversees the introduction and implementation of the new technology, equipment, systems and techniques into the center's production operations.

(2) Production Programs Modernization Division (PPM) which is responsible for assuring that the production elements have the knowledge, skills, and resources to move a segment or system into a production center while maintaining steady production. PPM ensures that the transition from current production procedures to automated methods proceeds smoothly and with minimal impact to the center.

Source: (DOD/DMA DPS Handbook, 1989:59-61)

Appendix E: Round One Delphi Survey

11 May 1990

Mr. P. R. Gilliam
Deputy Director Mgt/Tech
Defense Mapping Agency
8613 Lee Highway
Fairfax, VA 22031-2137

Dear Mr. Gilliam:

Thank you for agreeing to participate in this Air Force Institute of Technology (AFIT) Delphi survey. The purpose of this research is to identify logistics requirements that will improve operational support for DMA's automated cartographic or photogrammetric systems. The research will integrate the required management principles, life cycle phases, and logistical support elements for automated cartographic or photogrammetric systems.

By its nature, Delphi surveys are conducted in areas where little or no research data exists. The survey is administered to a select group of "expert" respondents; therefore, your response is extremely important. You were selected to participate in this research effort because your experience and knowledge qualify you as a cartographic or photogrammetric "expert". Your opinions and comments will be combined with those of other "experts" to develop a model describing logistical support planning requirements for automated cartographic or photogrammetric systems.

To assist in this research, please complete the survey and return it in the self-addressed envelope within one week of receipt. As soon as all the responses are compiled, a second iteration of the Delphi survey will be distributed to you.

Any comments, suggestions, and ideas regarding this research effort and the model are welcome. Please be assured that complete anonymity will be enforced. If you have any questions about the survey please have a member of your staff call Major Robert McCauley at (513) 255-4149 (AV 785-4149) or Thomas R. Mann at (513) 435-1461.

A synopsis of the survey results will be provided to you upon completion. Thank you for your time and sharing your expertise.

THOMAS R. MANN
DMASC/EG
LTFTT Student
Graduate Logistics Management Program
Air Force Institute of Technology (AFIT)

2 Atch
1. Delphi Survey
2. Return Envelope

SURVEY ON LOGISTICS SUPPORT PLANNING REQUIREMENTS FOR AUTOMATED CARTOGRAPHIC OR PHOTOGRAMMETRIC SYSTEMS

The purpose of this research is to identify logistics planning requirements that will improve operational support for DMA's automated cartographic or photogrammetric systems. To assess logistics planning requirements, this survey uses the Integrated Logistics Support (ILS) concept as a unifying structure for the research. ILS is the disciplined, unified, and iterative approach to the management and technical activities necessary to: (a) integrate support considerations into system and equipment design; (b) develop support requirements that are related consistently to readiness objectives, to design, and to each other; (c) acquire the required support; and (d) provide the required support during the operational phase at minimum cost.

It is important that all respondents share the same common understanding of important concepts. Three attachments describing the Logistics Systems Management Matrix (LSMM), Design or Life Cycle Phases, and ILS Elements are provided along with this questionnaire. Please review these attachments before you begin, and keep them beside you as you proceed with the survey for easy reference. <u>When instructed, please use the Attachments provided to clarify the meanings of important concepts</u>. Please complete the survey and return it in the self-addressed envelope <u>within one week of receipt</u>. As soon as all the responses are compiled, a second iteration of the Delphi survey will be distributed.

Some general guidelines for completing this survey are provided below.

a. When a question requires a multiple choice answer, please circle the appropriate number on that question.

b. When a question calls for an answer along a scale, please circle the number which most accurately reflects your judgement on that question or statement.

c. When a question requires a ranking response, please rank order the alternatives, using "1" for the most important item.

d. Please provide the rationale for your answers, especially for those areas where you feel strongly. Add any illustrations, examples, or experiences you have had that will help the other participants understand your response. Feel free to continue your comments on the back of the survey sheets.

e. Any ideas or recommendations you have for improving logistics support for automated cartographic or photogrammetric systems should also be included.

f. Please use the last page of this survey to provide additional comments you feel are pertinent to this study.

THANK YOU FOR PARTICIPATING IN THIS SURVEY.

TOPIC 1: BACKGROUND INFORMATION

The requested information documents the participation of "experts" from critical functional areas involved in the administration, research and development, operational use, and support/maintenance of cartographic or photogrammetric systems.

1. Your age is:

    [1] Less than 30
    [2] 31 to 40
    [3] 41 to 50
    [4] 51 to 60
    [5] More than 60

2. Your highest educational level obtained is:

    [1] High school graduate or GED
    [2] Some college work
    [3] Associate degree
    [4] Bachelors degree
    [5] Some graduate work
    [6] Master's degree
    [7] Master's degree plus additional graduate studies
    [8] Ph. D. or equivalent

3. How long have you been associated with Automated Cartographic and/or Photogrammetric Systems:

    [1] Less than 4 years
    [2] 4 years, but less than 8 years
    [3] 8 years, but less than 12 years
    [4] 12 years, but less than 16 years
    [5] 16 years, but less than 20 years
    [6] 20 years or more

4. What organization do you work for within the Defense Mapping Agency?

    [1] DMA Headquarters
    [2] DMA Systems Center
    [3] DMA Reston Center
    [4] DMA Hydrographic/Topographic Center
    [5] DMA Aerospace Center
    [6] Other ______________________________(please specify)

5. How do you categorize your organization's primary role in the delivery/use of automated cartographic or photogrammetric systems?

[1] Administrative
[2] Research and Development
[3] Operational Use (Production)
[4] Support and/or Maintenance
[5] Other ______________________________(please specify)

6. How long have you been employed with DMA?

[1] Less than 4 years
[2] 4 years, but less than 8 years
[3] 8 years, but less than 12 years
[4] 12 years, but less than 16 years
[5] 16 years, but less than 20 years
[6] 20 years or more

7. How long have you worked in your present position?

[1] Less than 1 year
[2] 1 year, but less than 2 years
[3] 2 years, but less than 3 years
[4] 3 years, but less than 4 years
[5] 4 years, but less than 5 years
[6] 5 years or more

8. What other organizations within DMA have you had experience in? (Check all appropriate choices)

[1] DMA Headquarters
[2] DMA Systems Center
[3] DMA Reston Center
[4] DMA Hydrographic/Topographic Center
[5] DMA Aerospace Center
[6] Other ______________________________(please specify)

9. Have you had experience as a user of DMA automated cartographic or photogrammetric systems outside of DMA?

[1] Yes (If yes, answer question 10)
[2] No

10. If so, What organization(s) outside of DMA?

_________________________________ (please specify)

____

With which DMA system(s) have you had experience?

_________________________________ (please specify)

____

TOPIC 2: BASIC CHARACTERISTICS

For questions numbered 11 through 23, please refer to the three-dimensional model known as the Logistics Systems Management Matrix (LSMM), provided at Attachment #1. Research has suggested that a model such as the Logistics Systems Management Matrix (LSMM) forms the basis for proper implementation of any given system. Certain sets of questions will require Attachments #2 and #3 to be used in conjunction with Attachment #1. Specific instructions will alert you to these special situations. The following questions will assist in determining the applicability of LSMM to automated cartographic or photogrammetric systems.

11. The LSMM provides a basic structure for outlining the logistics support of automated cartographic or photogrammetric systems.

1	2	3	4	5
highly disagree	disagree	neither agree nor disagree	agree	highly agree

12. How would you change the LSMM?

Please use Attachment #2 in conjunction with Attachment #1 to answer Questions #13 through #16.

13. An understanding of design or life cycle processes is important for logistics support planning of automated cartographic or photogrammetric systems.

1	2	3	4	5
highly disagree	disagree	neither agree nor disagree	agree	highly agree

14. This model accurately portrays the design or life cycle phases of automated cartographic or photogrammetric systems employed by DMA.

1	2	3	4	5
highly disagree	disagree	neither agree nor disagree	agree	highly agree

15. Rank order from 1 to 6 the design or life cycle phases in terms of importance for logistics support planning of DMA automated cartographic or photogrammetric systems? (Use "1" to denote the most important).

_____ Conceptual Phase

_____ Advanced Development Phase

_____ Detailed Design Phase

_____ Production

_____ Operational Use

_____ Retirement

16. How would you change the design or life cycle phases proposed in the LSMM?

<u>Please use Attachment #3 in conjunction with Attachment #1 to answer Questions #17 through #23</u>.

17. Understanding Integrated Logistics Support (ILS) is important for logistics support planning of automated cartographic or photogrammetric systems.

1	2	3	4	5
highly disagree	disagree	neither agree nor disagree	agree	highly agree

18. This model accurately portrays the ILS elements applied to automated cartographic or photogrammetric systems employed by DMA.

1	2	3	4	5
highly disagree	disagree	neither agree nor disagree	agree	highly agree

19. For the ILS elements listed below, what are the three most important and the three least important ILS elements associated with logistics support planning of automated cartographic or photogrammetric systems.

Using the left column rank the three most important ILS elements (Use "1" to denote the first, "2" to denote the second, "3" to denote the third). Using the right column rank the three least important ILS elements (Use "8" to denote the eighth, "9" to denote the ninth, "10" to denote the tenth).

Most Important Elements	Least Important Elements
_____ Maintenance Planning	_____ Maintenance Planning
_____ Manpower/Personnel	_____ Manpower/Personnel
_____ Supply Support	_____ Supply Support
_____ Support Equipment	_____ Support Equipment
_____ Technical Data	_____ Technical Data
_____ Training	_____ Training
_____ Computer Resources Support	_____ Computer Resources Support
_____ Facilities	_____ Facilities
_____ Packaging, Handling & Transportation	_____ Packaging, Handling & Transportation
_____ Design Interface	_____ Design Interface

20. Which of the ILS elements are not applicable to automated cartographic or photogrammetric systems? Why are they not applicable?

21. How would you change any of the ILS elements proposed in the LSMM?

22. Are there any elements in the logistics support planning of automated cartographic or photogrammetric systems not addressed by the LSMM model? Please specify and describe what these elements are.

23. To what extent does DMA employ ILS in logistics support requirements planning of automated cartographic or photogrammetric systems?

1	2	3	4	5
Not At All		To A Moderate Extent		To A Very Great Extent

TOPIC 3: ILS ELEMENTS AND LIFE CYCLE DETERMINATION & DESIGN REQUIREMENTS

For questions numbered 24 through 43 please reference Attachment #2 and #3. Life cycle phases are defined in Attachment #2 and ILS elements are defined in Attachment #3 to provide assistance in answering questions 24 through 43.

Provide comments on what factors, within each of the ILS elements listed below, are unique and require logistics support planning for automated cartographic or photogrammetric systems. After providing comments on each ILS element, please complete the questions concerning when in the life cycle of automated cartographic or photogrammetric systems should determination & design requirements for each ILS element take place.

24. Maintenance Planning: Please identify and explain maintenance planning factors unique to automated cartographic or photogrammetric systems. Provide examples of past experiences to support your comments.

25. At what stage of the automated systems' life cycle should maintenance planning requirements determination and design take place?

1	2	3	4	5
Conceptual Phase	Advanced Development Phase	Detailed Design Phase	Production Phase	Operational Use

26. Manpower and Personnel: Please identify and explain manpower and personnel factors unique to automated cartographic or photogrammetric systems. Provide examples of past experiences to support your comments.

27. At what stage of the automated systems' life cycle should manpower and personnel requirements determination and design take place?

1	2	3	4	5
Conceptual Phase	Advanced Development Phase	Detailed Design Phase	Production Phase	Operational Use

28. Supply Support: Please identify and explain supply support factors unique to automated cartographic or photogrammetric systems. Provide examples of past experiences to support your comments.

29. At what stage of the automated systems' life cycle should supply support requirements determination and design take place?

1	2	3	4	5
Conceptual Phase	Advanced Development Phase	Detailed Design Phase	Production Phase	Operational Use

30. Support Equipment: Please identify and explain support equipment factors unique to automated cartographic or photogrammetric systems. Provide examples of past experiences to support your comments.

31. At what stage of the automated systems' life cycle should support equipment requirements determination and design take place?

1	2	3	4	5
Conceptual Phase	Advanced Development Phase	Detailed Design Phase	Production Phase	Operational Use

32. Technical Data: Please identify and explain technical data factors unique to automated cartographic or photogrammetric systems. Provide examples of past experiences to support your comments.

33. At what stage of the automated systems' life cycle should technical data requirements determination and design take place?

1	2	3	4	5
Conceptual Phase	Advanced Development Phase	Detailed Design Phase	Production Phase	Operational Use

34. Training: Please identify and explain training factors unique to automated cartographic or photogrammetric systems. Provide examples of past experiences to support your comments.

35. At what stage of the automated systems' life cycle should training requirements determination and design take place?

1	2	3	4	5
Conceptual Phase	Advanced Development Phase	Detailed Design Phase	Production Phase	Operational Use

36. <u>Computer Resources Support</u>: Please identify and explain computer resources support factors unique to automated cartographic or photogrammetric systems. Provide examples of past experiences to support your comments.

37. At what stage of the automated systems' life cycle should computer resources support requirements determination and design take place?

1	2	3	4	5
Conceptual Phase	Advanced Development Phase	Detailed Design Phase	Production Phase	Operational Use

38. <u>Facilities</u>: Please identify and explain facilities factors unique to automated cartographic or photogrammetric systems. Provide examples of past experiences to support your comments.

39. At what stage of the automated systems' life cycle should facilities requirements determination and design take place?

1	2	3	4	5
Conceptual Phase	Advanced Development Phase	Detailed Design Phase	Production Phase	Operational Use

40. Packaging, Handling & Transportation: Please identify and explain packaging, handling, & transportation factors unique to automated cartographic or photogrammetric systems. Provide examples of past experiences to support your comments.

41. At what stage of the automated systems' life cycle should packaging, handling & transportation requirements determination and design take place?

1	2	3	4	5
Conceptual Phase	Advanced Development Phase	Detailed Design Phase	Production Phase	Operational Use

42. Design Interface: Please identify and explain design interface factors unique to automated cartographic or photogrammetric systems. Provide examples of past experiences to support your comments.

43. At what stage of the automated systems' life cycle should design interface requirements determination and design take place?

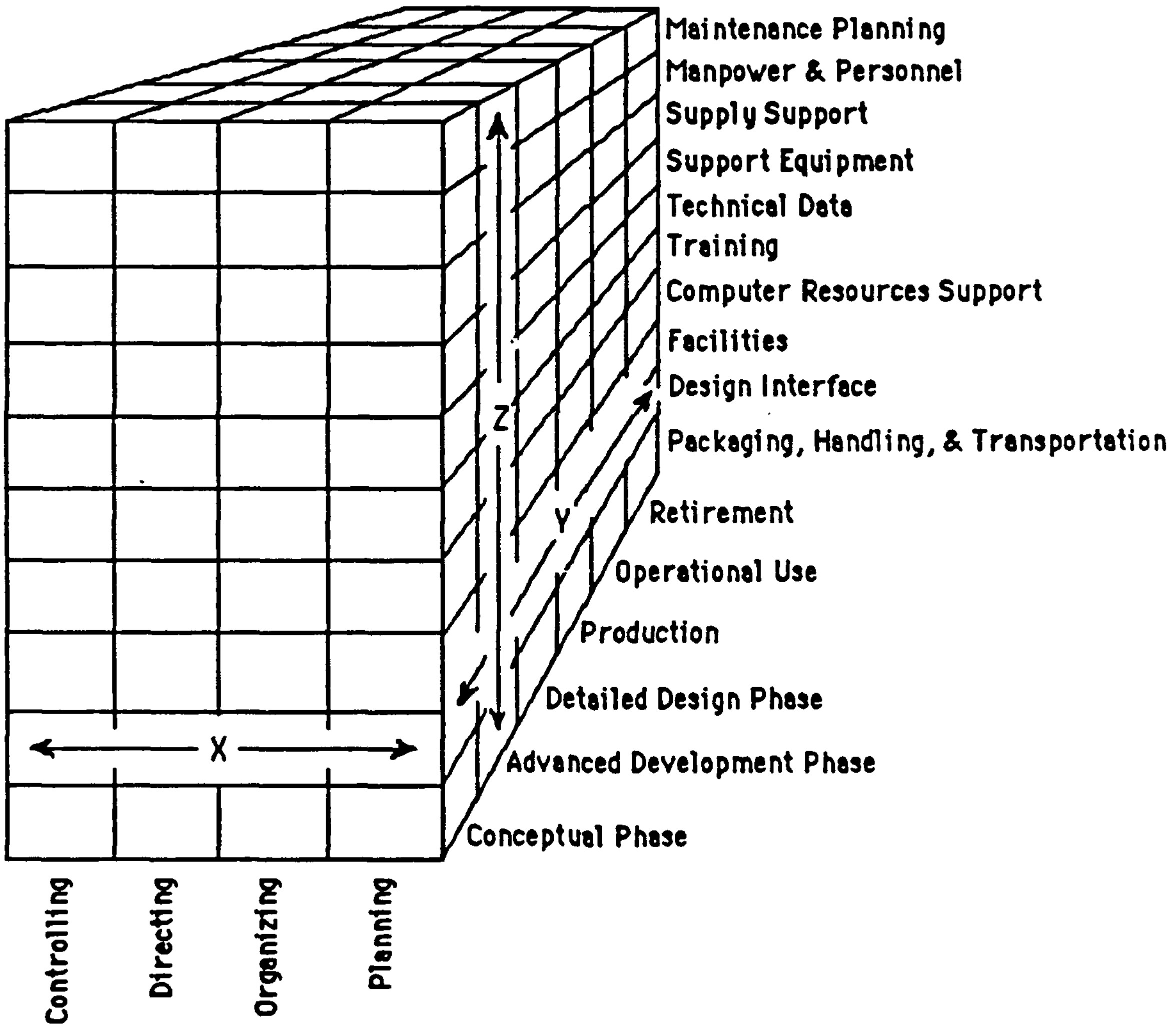
1	2	3	4	5
Conceptual Phase	Advanced Development Phase	Detailed Design Phase	Production Phase	Operational Use

ADDITIONAL COMMENTS:

How well does DMA apply ILS or any other logistics support planning process to automated cartographic or photogrammetric systems? Please describe any improvements which need to be made to this process. How would you suggest these improvements be accomplished?

LOGISTICS SYSTEMS MANAGEMENT MATRIX (LSMM)

Research has suggested that a model such as the Logistics Systems Management Matrix (LSMM) below forms the basis for proper implementation of any given system. The LSMM is a three-dimensional model with principles of management on the "X" axis, design or life cycle processes on the "Y" axis, and the ILS elements on the "Z" axis. Please use Attachment #1 as a reference in answering questions 11 through 22.



The Logistics Systems Management Matrix

ATTACHMENT #1

DESIGN OR LIFE CYCLE PHASES

1. Conceptual Phase: This phase is where the product or service system is defined, acquisition requirements are determined, production and operational support requirements are identified and logistics support planning is established.

2. Advanced Development Phase: This phase identifies and defines the product configuration. It deals with product objectives, performance limits, areas of risk, alterations and acquisition methodologies. During this phase, logistics support analysis is conducted to verify design concepts, followed by the initiation of the logistics support plan.

3. Detailed Design Phase: This phase includes the design and test of the product. It consists of design effects on reliability, maintainability, sustainability, human factors issues and logistics support. Engineering modes and prototypes are developed. At this time, the formal logistic support plan is completed.

4. Production Phase: This phase consists of producing the product and its support, such as test and support equipment, spare parts, training personnel, software, physical distribution and transportation, and warehousing.

5. Operational Use: This phase covers all of the activities associated with consumer use and logistics support, to include maintenance and sustainability.

6. Retirement: This phase consists of all of the actions necessary to phase out and dispose of the system, to include waste management, recycling or other responsive actions. Fast obsolescence systems, such as automated cartographic or photogrammetric systems, require retirement planning early in the life cycle to ensure proper phase-out of old systems and implementation of new systems.

ATTACHMENT #2

ILS ELEMENTS

The following ILS definitions come from the Integrated Logistics Support Guide published by the Defense Systems Management College. Each definition is a short synopsis for that particular ILS element. Please use the ILS definitions provided in Attachment #2 as a reference in answering Questions 23 through 42.

1. Maintenance Planning: The process conducted by the Government and contractor to explore alternatives and to develop the maintenance concepts and maintenance requirements for the life of the material system. Maintenance planning is the lead analytical activity and provides input to the development of all of the remaining logistics support elements.

2. Manpower and Personnel: The element which encompasses the identification and acquisition of military and civilian personnel with the skills and grades required to operate and support a material system over its lifetime at peacetime and wartime rates.

3. Supply Support: The element which encompasses all actions required to identify and obtain the spares and repair parts needed to support peacetime and wartime readiness objectives.

4. Support Equipment: The element which encompasses all equipment required to support operation and maintenance of the material system. This includes ground handling equipment, tools, metrology and calibration equipment, test equipment, and logistic support for the support equipment.

5. Technical Data: The element which encompasses all recorded information of a scientific or technical nature related to a program. Technical data are written instructions such as drawings; operating and maintenance manuals; specifications, inspection, test and calibration procedures; and computer programs which guide personnel performing operations and support tasks.

6. Training: The element which encompasses all of the processes, procedures, techniques, training devices and equipment used to train personnel to operate and support a material system. Examples include individual and group training; new equipment training; initial, formal and on-the-job training; and logistic support planning for training equipment.

ATTACHMENT #3

7. Computer Resources Support: The element is defined as all computer equipment, software, associated documentation, contractual services, personnel, and supplies needed to operate and support an embedded computer system.

8. Facilities: The element which encompasses those real property assets required to support the material system, and the studies which define types of facilities or facility improvements, locations, space needs, etc.

9. Packaging, Handling & Transportation: The element which includes the characteristics, action and requirements necessary to ensure the capability to transport, preserve, package, and handle all equipment and support items.

10. Design Interface: The element which is an interactive relationship of logistics-related design parameters, such as R&M, to readiness and logistic support resource requirements.

ATTACHMENT #3

Appendix F: Round One Delphi Survey Comments

Basic Characteristics of the LSMM Model.

Basic Structure.

How would you change the LSMM?

"Reverse the Z-Axis so that maintenance planning is at the same origin point as planning and conceptual phase, this will show the growth of a 3-D solid from ground up."

"Add resources = $$."

"Add a new element on the "Y" axis between Production and Operational Use entitled "Transition" to allow an implementation period for the new system."

"Restructure it to apply to DMA; training, facilities, maintenance and production are all handled by different directorates within DMA rather than under one management structure."

"Include test equipment as a separate element."

"Software maintenance and continual enhancement is perhaps the most critical item in the continuing life cycle support of automated cartographic and photogrammetric systems. It is inadequately addressed by lumping software under Technical Data and Computer Resources Support."

"Add delegation to the "X" axis. Delete "advanced" on the "Y" axis and add delivery, installation, test and acceptance, and operational refinement. Add maintenance of system to the "Z" axis."

"Explain the "Z" axis relationships. Are they rank ordered? I am assuming they are a listing used to determine what ILS elements are required during different management and life cycle phases.

"I believe reviewing is part of the "X" axis."

"Don't have enough experience or knowledge with the model to suggest changes- Seems comprehensive.'

"All the blocks are the same size. If the amount of resources could be incorporated, the blocks would be variably sized. Also, "Advanced Design Phase" should be "Preliminary Design Phase". For most development today, the

terminology is (1) Design Concept; (2) Preliminary Design; (3) Critical Design. Remove "Planning" from "Maintenance Planning". Is this a solid volume? Or are there holes in the middle if some of the blocks really don't apply (such as Computer Resources, Organizing for Retirement)?"

"Change the description of the LSMM on attachment #1 to read: ..., forms the basis for proper implementation of a logistics support system for any given system. If it is intended to describe the implementation of a total system end-to-end, it is too weak in the front-end dealing with requirements definition." Add "Funding" to the "X" axis."

"Separate maintenance into hardware and software maintenance."

Design or Life Cycle Processes.

How would you change the design or life cycle phases proposed in the LSMM?

"Software(modification, configuration control, upgrade, and interface with external system) should be fully addressed in Detailed Design Phase."

"Add Transition Phase between Production and Operational Use."

"Combine conceptual and advanced development phase."

"Change the names to reflect what DMA calls them- while we generally follow the DOD phases we call them something different."

"Add a process improvement block after operational use. Most DMA systems go through considerable process improvements after FOC."

"The Operational phase is conceived as merely being the use of the "product". In reality, life cycle phases 1-4 normally continue to reoccur repeatedly throughout the operational life of automated cartographic and photogrammetric systems. In my experience seldom if ever has a production system been the same "product" at the end of its life cycle as was envisioned at the start of its operational use."

"There is too much variation in "Operational Use" to lump it all together. Break it out into three categories: initial burn in period, steady state, and advanced age."

"We should just stick to them. Now we almost always take an R & D prototype system and make it a production system."

"Change arrangement to Design Concept, Preliminary Design, Critical Design, Build-to, Production, and Retirement."

"For developing logistics support, the phases are accurate as described."

"They should agree with the new DOD 5000.1."

Integrated Logistics Support (ILS) Elements.

Which of the ILS elements are not applicable to automated cartographic or photogrammetric systems? Why are they not applicable?

"Design Interface- I am not sure what this is supposed to be with respect to these systems."

"The Design Interface is often not applicable. Much of the hardware is Commercial Off-the-Shelf (COTS) and we have little input into its design."

"Manpower/Personnel- DMA is authorized "X" numbers of employees yearly. The priority and production rates determine the numbers of people to operate these systems."

"All are applicable, all are important, but some can be made part of the Acquisition Contract."

"Manpower/Personnel- not part of ILS part of programming and budgeting process."

"Manpower/Personnel may not be applicable in the DMA environment because of our structured environment. The time frames involved in justifying and staffing new positions, particularly in a time of declining budgets makes it difficult to get the people needed in the time frame involved."

"If anyone says an ILS element is not applicable to automated cartographic or photogrammetric systems I would discount his/her entire survey- the individual obviously doesn't comprehend ILS."

"We traditionally have not included some in ILS planning (manpower, training, and computer resources support) but had these covered by people dealing with transition."

"Packaging, handling, and transportation- the DMA systems are static and are rarely moved once installed."

"The description of "Design Interface" is not clear."

How would you change any of the ILS elements proposed in the LSMM?

"Design interface needs to be more clearly described and explained."

"There should be a separate element for applications software. Software should not be lumped under Technical data."

"Would recognize that development contractor should/could provide some of the elements."

"I don't think design interface is applicable."

"Add Security Support."

"For many of the elements the support required for the development is determined separately from that for maintenance. These include: Manpower, Training, Computer Resources and Facilities. Maintenance requirements in these areas are only part of the total requirement."

Are there any elements in the logistics support planning of automated cartographic or photogrammetric systems not addressed by the LSMM model? Please specify and describe what these elements are.

"Contractor interface important where equipments are very unique."

"Highly dependent on communication - narrow band and wide band, fiber optics, ethernet, and switching and transmission gear; may need a separate communication category."

"ILS documentation usually contains a safety chapter or annex. Safety needs to be addressed in your model, but I am not sure how because it cuts across most of your categories."

"This model fails to recognize the fundamental nature of these systems, which is that they are a part of a production <u>process</u>. These processes and the systems necessarily change and evolve as improvements are made to increase productivity and as new or changed products are introduced into the production line. Automated cartographic or photogrammetric systems evolve during their life cycle so that they are often very different from their initial configuration and use in operation. Changes are made in both system hardware and software to effect this evolution. The ability to constantly modify and improve applications software is particularly crucial to the production use of these systems. Applications software is very much an extension of the

cartographer or photogrammetrist. It is probably not useful or meaningful to try to separate conceptually software maintenance from software development or enhancement. The basic problem with the model presented in that it is linear, when the actual life cycle for these systems involves an iterative development and operational cycle."

"Should security be added as an additional logistics element?"

"If you include DMA's traditional "transition" events then you are missing Demonstrations (to prove system meets requirements) and Exercise and Rehearsals (to familiarize workers with the system prior to production."

"Security is a major issue and requires special attention. Calibration is a significant element on some systems."

<u>Logistics Support Planning Applications within DMA</u>.

> How well does DMA apply ILS or any other logistics support planning process to automated cartographic or photogrammetric systems? Please describe any improvements which need to be made to this process. How would you suggest these improvements be accomplished?

"Currently, the planning process is not done as soon as it should be- on small procurements it is an afterthought. Personnel need to be trained to think ILS during development."

"Very poorly. There is no integrated approach to logistics support planning. Individual elements are addressed separately and some of those elements are not even considered part of the ILS process. The only real elements DMA addresses as part of logistics support are maintenance supply, and support and test equipment. The other elements are not really recognized as part of the ILS process. DMA needs to place more emphasis on <u>integrating</u> all of the elements into a comprehensive and cohesive ILS program. More emphasis needs to placed on design interface in order to influence design for supportability in the <u>early</u> phases of system development. Additionally, the program managers must be made responsible for considering life cycle support, and therefore ILS, during system design and manufacture. The PM's must recognize their responsibility for integrating ILS as one of the program management elements."

"DMA needs more involvement during the Advanced Development and Detailed Design Phases in order to do a better job of supporting cartographic and photogrammetric systems.

"From my perspective, DMA does not do a good job of planning."

"Poorly- we are at least one year behind but we have contractors in place to support until we have our sea legs."

"Generally, in the past the logistics support for production systems has been adequate for production needs, which would indicate some planning process. Production departments generally supplied their own software maintenance. Reorganizations of maintenance responsibilities and increased reliance of contractor maintenance in recent years has generally lead to a decrease in the level of satisfaction on the production organizations in part."

"I saw little evidence of an ILS approach to our past systems. I do see an attempt to provide ILS to our new systems. Unfortunately, obstacles are constantly being placed in our way. Logistics is viewed as obstacle by many of the COTR type people. We need more influence earlier in the system design phases."

"Haphazardly- not enough firm financial commitment to adequately support a system. There needs to be a Logistics Directorate whose sole responsibility is maintenance without interference from the Centers or other departments with the exception of communication during times of crisis. DMA needs to get a vision of maintenance as supporting production rather than "fix it if it breaks". I would call a strong logistics organization in DMA a safeguard on the vast investment the government has made in DMA."

"DMA appears to do a great deal of planning but does not do a good job of implementing the plan. Maintenance people are often not adequately trained to support the system, spare parts are often not maintained, equipment status reports are not adequately reviewed or trend analysis performed and preventive maintenance is often not performed. I would review the completed DMA support function from top to bottom and execute a plan to raise the level of performance.

"Very poorly- Didn't apply the ILS early enough. Minimal planning in early stages. Now we are playing catch up through the RFC process."

"Fair- More responsiveness/accountable to Production Center requirements with Cost Benefit Analysis of what work/$ = most beneficial to DMA, not who has what training and is available or what crisis happens to call for $ when $ are available."

"Varies- MARK 85 and MARK 90 ILS very well done. Piecemeal buys are of great variety, some good and some non-existent."

"The one area that DMA historically has ignored is the application of ILS during the conceptual phase of development rather than at the operational phase. MARK 85 and MARK 90 systems are examples of how DMA is changing with respect to ILS. DMA needs to follow the formal processes of the life cycles of systems in a more rigorous manner for all systems, as is being done for MARK 90."

"I believe that DMA does a reasonably good job of dealing with systems development and operation. However, we do not approach it in the same way as espoused by the USAF. In recent times we have had agency directors who have tried to dictate organizational and process changes to get more in line and I have yet to see the benefits- perhaps somewhere in the future they will pay off."

"DMA hasn't done this very well in the past. As a result, DMA Director is creating a Directorate for Acquisition, Installation, and Logistics. ADD/Logistics includes four divisions: Logistics Plans, Distribution, Maintenance, and Supply. This will eliminate many of DMA's fragmented logistics activities and result in a proactive consolidated logistics organization that is more capable of developing, planning, and implementing true ILS."

"We take too long to start the process, as a result ILS doesn't do what it is intended to do (decisions have already been made)."

"We have done reasonably well with the Digital Production System and subsequent large procurements."

"ILS is a major player. Systems could not be delivered or maintained, facilities would not be adequate, and personnel wouldn't be trained without ILS. ILS has always been a fuzzy area that I always relied on a logistics person to work. I provided the logistics office the technical specs of what was needed by when, and they always came through."

"Not very well- The MARK 90 development is trying to establish system level requirements documents for ILS which will help. Problem is that <u>content</u> requirements of the documents are overlooked. Biggest improvement: Start planning earlier."

Appendix G: Round Two Delphi Survey

20 June 1990

Mr. M. Z. Labovitz
Director, Acquisition Office
Defense Mapping Agency
8613 Lee Highway
Fairfax, VA 22031-2137

Dear Mr. Labovitz:

Thank you for completing the first round of the AFIT Delphi Survey on Logistics Support Planning Requirements for Automated Cartographic or Photogrammetric Systems. Your comments were of great value to this research. Enclosed you will find the second round of the Delphi survey containing respondent feedback. Please return your completed second round survey <u>within one week</u>; it is essential to have timely and complete participation in order to assure successful completion of the Thesis effort.

I am certain you will find the comments of other DMA experts interesting. Not all questions require answers in the second round because consensus was reached in the first round of the Delphi Survey. The criterion for consensus was established at 60% agreement on a single response item. The percent of consensus agreement is provided for each answer. The questions requiring a new response are <u>asterisked</u> and are accompanied by the statement "Your New Response". Mean ratings and/or comments are provided to assist you in completing these questions. Please consider all the feedback in making your responses on the second round of the survey.

You should find the second round of the survey easier and faster to complete, as it requires fewer numerical responses. Please review the qualitative comments and provide your reactions to and/or synthesis of these comments. If you have any questions about the survey please call Major Robert McCauley at (513) 255-4149 (AV 785-4149) or Thomas R. Mann at (513) 435-1461.

A synopsis of the survey results will be provided to you upon completion. Thank you again for taking the time and helping us learn more about logistics support planning requirements for automated cartographic or photogrammetric systems. Please return the survey within one week.

THOMAS R. MANN
DMASC/EG
LTFTT Student
Graduate Logistics Management Program
Air Force Institute of Technology (AFIT)

2 Atch
1. Delphi Survey
2. Return Envelope

SURVEY ON LOGISTICS SUPPORT PLANNING REQUIREMENTS FOR AUTOMATED CARTOGRAPHIC OR PHOTOGRAMMETRIC SYSTEMS

The purpose of this research is to identify logistics planning requirements that will improve operational support for DMA's automated cartographic or photogrammetric systems. To assess logistics planning requirements, this survey uses the Integrated Logistics Support (ILS) concept as a unifying structure for the research. ILS is the disciplined, unified, and iterative approach to the management and technical activities necessary to: (a) integrate support considerations into system and equipment design; (b) develop support requirements that are related consistently to readiness objectives, to design, and to each other; (c) acquire the required support; and (d) provide the required support during the operational phase at minimum cost.

It is important that all respondents share the same common understanding of important concepts. Three attachments describing the Logistics Systems Management Matrix (LSMM), Design or Life Cycle Phases, and ILS Elements are provided along with this questionnaire. Please review these attachments before you begin, and keep them beside you as you proceed with the survey for easy reference. <u>When instructed, please use the Attachments provided to clarify the meanings of important concepts</u>. Please complete the survey and return it in the self-addressed envelope <u>within one week of receipt</u>. As soon as all of the second round responses are compiled, a synopsis of the survey results will be distributed.

Some general guidelines for completing this survey are provided below.

a. Please consider the feedback provided before you respond to the questions.

b. When a question calls for an answer along a scale, please circle the number which most accurately reflects your judgement on that question or statement.

c. When a question requires a ranking response, please rank order the alternatives, using "1" for the most important item.

d. Please provide the rationale for your answers, especially for those areas where you feel strongly. Add any illustrations, examples, or experiences you have had that will help the other participants understand your response. Feel free to continue your comments on the back of the survey sheets.

e. Any ideas or recommendations you have for improving logistics support for automated cartographic or photogrammetric systems should also be included.

f. Please use the last page of this survey to provide additional comments you feel are pertinent to this study.

THANK YOU FOR PARTICIPATING IN THIS SURVEY.

TOPIC 2: BASIC CHARACTERISTICS

For questions numbered 11 through 23, please refer to the three-dimensional model known as the Logistics Systems Management Matrix (LSMM), provided at Attachment #1. Research has suggested that a model such as the Logistics Systems Management Matrix (LSMM) forms the basis for proper implementation of any given system. Certain sets of questions will require Attachments #2 and #3 to be used in conjunction with Attachment #1. Specific instructions will alert you to these special situations. The following questions will assist in determining the applicability of LSMM to automated cartographic or photogrammetric systems.

11. The LSMM provides a basic structure for outlining the logistics support of automated cartographic or photogrammetric systems.

ROUND 1 CONSENSUS: 81% AGREE OR HIGHLY AGREE.

**12. How would you change the LSMM?

ROUND 1 COMMENTS:

"Reverse the Z-Axis so that maintenance planning is at the same origin point as planning and conceptual phase, this will show the growth of a 3-D solid from ground up."

"Add resources = $$."

"Add a new element on the "Y" axis between Production and Operational Use entitled "Transition" to allow an implementation period for the new system."

"Restructure it to apply to DMA; training, facilities, maintenance and production are all handled by different directorates within DMA rather than under one management structure."

"Include test equipment as a separate element."

"Software maintenance and continual enhancement is perhaps the most critical item in the continuing life cycle support of automated cartographic and photogrammetric systems. It is inadequately addressed by lumping software under Technical Data and Computer Resources Support."

"Add delegation to the "X" axis. Delete "advanced" on the "Y" axis and add delivery, installation, test and acceptance, and operational refinement. Add maintenance of system to the "Z" axis."

"Explain the "Z" axis relationships. Are they rank ordered? I am assuming they are a listing used to determine what ILS elements are required during different management and life cycle phases.

"I believe reviewing is part of the "X" axis."

"Don't have enough experience or knowledge with the model to suggest changes- Seems comprehensive."

"All the blocks are the same size. If the amount of resources could be incorporated, the blocks would be variably sized. Also, "Advanced Design Phase" should be "Preliminary Design Phase". For most development today, the terminology is (1) Design Concept; (2) Preliminary Design; (3) Critical Design. Remove "Planning" from "Maintenance Planning". Is this a solid volume? Or are there holes in the middle if some of the blocks really don't apply (such as Computer Resources, Organizing for Retirement)?"

"Change the description of the LSMM on attachment #1 to read: ..., forms the basis for proper implementation of <u>a logistics support system</u> for any given system. If it is intended to describe the implementation of a total system end-to-end, it is too weak in the front-end dealing with requirements definition." Add "Funding" to the "X" axis."

"Separate maintenance into hardware and software maintenance."

YOUR NEW COMMENTS:

Please use Attachment #2 in conjunction with Attachment #1 to answer Questions #13 through #16.

13. An understanding of design or life cycle processes is important for logistics support planning of automated cartographic or photogrammetric systems.

ROUND 1 CONSENSUS: 100% AGREE OR HIGHLY AGREE.

14. This model accurately portrays the design or life cycle phases of automated cartographic or photogrammetric systems employed by DMA.

ROUND 1 CONSENSUS: 65% AGREE OR HIGHLY AGREE.

**15. Using the mean/rank method, the mean responses from Round 1 were ranked from 1 to 6. The only consensus response was Retirement, which was ranked #6. Please rank order from 1 to 5 the design or life cycle phases in terms of importance for logistics support planning of DMA automated cartographic or photogrammetric systems? (Use "1" to denote the most important).

ROUND 1 RESPONSES:

_____	Detailed Design Phase	(ROUND 1 MEAN: 2.387)
_____	Advanced Development Phase	(ROUND 1 MEAN: 2.581)
_____	Production Phase	(ROUND 1 MEAN: 3.290)
_____	Operational Use Phase	(ROUND 1 MEAN: 3.323)
_____	Conceptual Phase	(ROUND 1 MEAN: 3.654)
6	Retirement	(ROUND 1 CONSENSUS: 87%)

**16. How would you change the design or life cycle phases proposed in the LSMM?

ROUND 1 COMMENTS:

"Software(modification, configuration control, upgrade, and interface with external system) should be fully addressed in Detailed Design Phase."

"Add Transition Phase between Production and Operational Use."

"Combine conceptual and advanced development phase."

"Change the names to reflect what DMA calls them- while we generally follow the DOD phases we call them something different."

"Add a process improvement block after operational use. Most DMA systems go through considerable process improvements after FOC."

"The Operational phase is conceived as merely being the use of the "product". In reality, life cycle phases 1-4 normally continue to reoccur repeatedly throughout the operational life of automated cartographic and photogrammetric systems. In my experience seldom if ever has a production system been the same "product" at the end of its life cycle as was envisioned at the start of its operational use."

"There is too much variation in "Operational Use" to lump it all together. Break it out into three categories: initial burn in period, steady state, and advanced age."

"We should just stick to them. Now we almost always take an R & D prototype system and make it into a production system."

"Change arrangement to Design Concept, Preliminary Design, Critical Design, Build-to, Production, and Retirement."

"For developing logistics support, the phases are accurate as described."

"They should agree with the new DOD 5000.1."

YOUR NEW COMMENTS:

Please use Attachment #3 in conjunction with Attachment #1 to answer Questions #17 through #23.

17. Understanding Integrated Logistics Support (ILS) is important for logistics support planning of automated cartographic or photogrammetric systems.

ROUND 1 CONSENSUS: 94% AGREE OR HIGHLY AGREE.

**18. This model accurately portrays the ILS elements applied to automated cartographic or photogrammetric systems employed by DMA.

ROUND 1 MEAN: 3.200

YOUR NEW RESPONSE:

1	2	3	4	5
highly disagree	disagree	neither agree nor disagree	agree	highly agree

**19. A weighting factor was assigned to each response to determine the three MOST important ILS elements associated with logistics support planning of automated cartographic or photogrammetric systems. A value of "5" was assigned to each ILS element with a "1" response; a value of "3" was assigned to each ILS element with a "2" response; and a value of "1" was assigned to each ILS element with a "3" response. The total value of each ILS element was used to determine the overall ranking, from TOP TO BOTTOM, of THE MOST IMPORTANT ILS ELEMENTS.

The only consensus response was Maintenance Planning, which was found to be the most important or "1". Please rank the second and third most important ILS elements (Use "2" to denote the second, "3" to denote the third).

Most Important Elements

1	Maintenance Planning	(ROUND 1 CONSENSUS: 62%)
_____	Manpower/Personnel	(ROUND 1 VALUE: 54)
_____	Training	(ROUND 1 VALUE: 35)
_____	Supply Support	(ROUND 1 VALUE: 23)
_____	Design Interface	(ROUND 1 VALUE: 18)
_____	Technical Data	(ROUND 1 VALUE: 16)
_____	Computer Resources Support	(ROUND 1 VALUE: 10)
_____	Facilities	(ROUND 1 VALUE: 09)
_____	Support Equipment	(ROUND 1 VALUE: 05)
_____	Packaging, Handling & Transportation	(ROUND 1 VALUE: 00)

**19A. A weighting factor was assigned to each response to determine the three LEAST important ILS elements associated with logistics support planning of automated cartographic or photogrammetric systems. A value of "5" was assigned to each ILS element with a "10" response; a value of "3" was assigned to each ILS element with a "9" response; and a value of "1" was assigned to each ILS element with a "8" response. The total value of each ILS element was used to determine the overall ranking, from TOP TO BOTTOM, of the LEAST IMPORTANT ILS ELEMENTS.

Please rank the three least important ILS elements (Use "8" to denote the eighth, "9" to denote the ninth, "10" to denote the tenth).

Least Important Elements

_____	Packaging, Handling & Transportation	(ROUND 1 VALUE: 110)
_____	Design Interface	(ROUND 1 VALUE: 62)
_____	Facilities	(ROUND 1 VALUE: 35)
_____	Computer Resources Support	(ROUND 1 VALUE: 24)
_____	Support Equipment	(ROUND 1 VALUE: 15)
_____	Supply Support	(ROUND 1 VALUE: 15)
_____	Manpower/Personnel	(ROUND 1 VALUE: 09)
_____	Technical Data	(ROUND 1 VALUE: 02)
_____	Training	(ROUND 1 VALUE: 00)
_____	Maintenance Planning	(ROUND 1 VALUE: 00)

**20. Which of the ILS elements are not applicable to automated cartographic or photogrammetric systems? Why are they not applicable?

ROUND 1 COMMENTS:

"Design Interface- I am not sure what this is supposed to be with respect to these systems."

"The Design Interface is often not applicable. Much of the hardware is COTS and we have little input into its design."

"Manpower/Personnel- DMA is authorized "X" numbers of employees yearly. The priority and production rates determine the numbers of people to operate these systems."

"All are applicable, all are important, but some can be made part of the Acquisition Contract."

"Manpower/Personnel- not part of ILS part of programming and budgeting process."

"Manpower/Personnel may not be applicable in the DMA environment because of our structured environment. The time frames involved in justifying and staffing new positions, particularly in a time of declining budgets makes it difficult to get the people needed in the time frame involved."

"If anyone says an ILS element is not applicable to automated cartographic or photogrammetric systems I would discount his/her entire survey- the individual obviously doesn't comprehend ILS."

"We traditionally have not included some in ILS planning (manpower, training, and computer resources support) but had these covered by people dealing with transition."

"Packaging, handling, and transportation- the DMA systems are static and are rarely moved once installed."

"The description of "Design Interface" is not clear."

YOUR NEW COMMENTS:

**21. How would you change any of the ILS elements proposed in the LSMM?

ROUND 1 COMMENTS:

"Design interface needs to be more clearly described and explained."

"There should be a separate element for applications software. Software should not be lumped under Technical data."

"Would recognize that development contractor should/could provide some of the elements."

"I don't think design interface is applicable."

"Add Security Support."

"For many of the elements the support required for the development is determined separately from that for maintenance. These include: Manpower, Training, Computer Resources and Facilities. Maintenance requirements in these areas are only part of the total requirement."

YOUR NEW COMMENTS:

**22. Are there any elements in the logistics support planning of automated cartographic or photogrammetric systems not addressed by the LSMM model? Please specify and describe what these elements are.

ROUND 1 COMMENTS:

"Contractor interface important where equipments are very unique."

"Highly dependent on communication - narrow band and wide band, fiber optics, ethernet, and switching and transmission gear; may need a separate communication category."

"ILS documentation usually contains a safety chapter or annex. Safety needs to be addressed in your model, but I am not sure how because it cuts across most of your categories."

"This model fails to recognize the fundamental nature of these systems, which is that they are a part of a production <u>process</u>. These processes and the systems necessarily change and evolve as improvements are made to increase productivity and as new or changed products are introduced into the production line. Automated cartographic or photogrammetric systems evolve during their life cycle so that they are often very different from their initial configuration and use in operation. Changes are made in both system hardware and software to effect this evolution. The ability to constantly modify and improve applications software is particularly crucial to the production use of these systems. Applications software is very much an extension of the cartographer or photogrammetrist. It is probably not useful or meaningful to try to separate conceptually software maintenance from software development or enhancement. The

basic problem with the model presented in that it is linear, when the actual life cycle for these systems involves an iterative development and operational cycle."

"Should security be added as an additional logistics element?"

"If you include DMA's traditional "transition" events then you are missing Demonstrations (to prove system meets requirements) and Exercise and Rehearsals (to familiarize workers with the system prior to production."

"Security is a major issue and requires special attention. Calibration is a significant element on some systems."

YOUR NEW COMMENTS:

**23. To what extent does DMA employ ILS in logistics support requirements planning of automated cartographic or photogrammetric systems?

ROUND 1 MEAN: 2.759

YOUR NEW RESPONSE:

1	2	3	4	5
Not At All		To A Moderate Extent		To A Very Great Extent

TOPIC 3: ILS ELEMENTS AND LIFE CYCLE DETERMINATION & DESIGN REQUIREMENTS

For questions numbered 24 through 43 please reference Attachment #2 and #3. Life cycle phases are defined in Attachment #2 and ILS elements are defined in Attachment #3 to provide assistance in answering questions 24 through 43.

For each ILS element a list of factors unique to automated cartographic or photogrammetric systems was collated from Round 1 responses. Review each list and provide the three most important factors, for each ILS element, that are unique to automated cartographic or photogrammetric systems. If required, please complete the questions concerning when in the life cycle of automated cartographic or photogrammetric systems should determination & design requirements for each ILS element take place.

**24. Maintenance Planning: The following list of maintenance planning factors unique to automated cartographic or photogrammetric systems was collated from Round 1 responses. Please review the list and provide the three most important maintenance planning factors unique to automated cartographic or photogrammetric systems.

ROUND 1 RESPONSES:

1. Adaptive hardware/software maintenance
2. Corrective hardware/software maintenance
3. Critical/preliminary design review of maintenance documents
4. Determine whether maintenance support will be in-house or contract
5. Failure rates hard to predict due to changing production priorities for systems
6. Lack of application of standard techniques or terminology
7. Logisticians must be involved in system development to adequately plan for maintenance support
8. Maintenance of electrical boards
9. Maintenance planning should be a continuous process throughout the life cycle of these systems
10. Maintenance security issues associated with volatile/non-volatile memory
11. Must conform to existing logistics maintenance planning guidelines
12. No unique factors-same as any workstation automated system
13. On call maintenance procedures should be established
14. Plan for possible default by contractors after turnover
15. Preventive hardware/software maintenance
16. Preliminary design review of maintenance documents
17. Rapid obsolescence
18. Sensitive security requirements
19. Special skills to maintain unique equipment (Automatic correlation equipment, optics)

**Please provide the numbers of the three most important maintenance planning factors.

_____ _____ _____

**25. At what stage of the automated systems' life cycle should maintenance planning requirements determination and design take place?

ROUND 1 MEAN: 2.214

YOUR NEW RESPONSE:

1	2	3	4	5
Conceptual Phase	Advanced Development Phase	Detailed Design Phase	Production Phase	Operational Use

**26. Manpower and Personnel: The following list of manpower and personnel factors unique to automated cartographic or photogrammetric systems was collated from Round 1 responses. Please review the list and provide the three most important manpower and personnel factors unique to automated cartographic or photogrammetric systems.

ROUND 1 RESPONSES:

1. Ability to retain competent personnel
2. Additional personnel in communication, optics, and unique electronics
3. Cadre of personnel should remain with the system from development through operational use
4. Education and technical background of users
5. Fatigue and boredom
6. Lead time for security clearances
7. Limited skilled personnel to maintain hardware and software
8. Operational planning the key driver of manpower requirements
9. Physical/technical skills required for photogrammetric work
10. Professional cartographic work force
11. Proper planning for staffing the automated systems
12. Require that more than two hardware maintenance personnel have knowledge of any one system
13. Stereo acuity
14. Systems need to be designed and maintained to meet requirements of production manpower and personnel

**Please provide the numbers of the three most important manpower and personnel factors.

______ ______ ______

**27. At what stage of the automated systems' life cycle should manpower and personnel requirements determination and design take place?

ROUND 1 MEAN: 2.552

YOUR NEW RESPONSE:

1	2	3	4	5
Conceptual Phase	Advanced Development Phase	Detailed Design Phase	Production Phase	Operational Use

**28. <u>Supply Support</u>: The following list of supply support factors unique to automated cartographic or photogrammetric systems was collated from Round 1 responses. Please review the list and provide the <u>three</u> most important supply support factors unique to automated cartographic or photogrammetric systems.

ROUND 1 RESPONSES:

1. Adequate shelf stock of required parts
2. COTS equipment has impact on the provisioning process, proprietary data rights, and basic supply support concept
3. Dependent on local purchase due to unique spares not being stocked in DOD supply system
4. Hardware life cycle is over before systems are in full production
5. Initial spare start-up quantities
6. Large computer maintenance contracts
7. Optical components
8. Staging of spares
9. Steady state life cycle spare requirements
10. Tapes, removable drives, plotter pens, plotter paper
11. Unique systems need unique spares, requiring long lead time

**Please provide the numbers of the <u>three</u> most important supply support factors.

______ ______ ______

29. At what stage of the automated systems' life cycle should supply support requirements determination and design take place?

ROUND 1 CONSENSUS: 68% AGREE ON DETAILED DESIGN PHASE.

**30. Support Equipment: The following list of support equipment factors unique to automated cartographic or photogrammetric systems was collated from Round 1 responses. Please review the list and provide the three most important support equipment factors unique to automated cartographic or photogrammetric systems.

ROUND 1 RESPONSES:

1. Calibration of support and test equipment
2. Calibration of photogrammetric equipment is critical
3. Design for easily replaced logical units, which are easily repaired
4. Electronic circuit board testing and analysis equipment
5. Identification of support and test equipment
6. Infreometers
7. Optical alignment equipment
8. Resolution targets
9. Screen luminance measuring equipment
10. Signal generators
11. Unique IBM gear

**Please provide the numbers of the three most important support equipment factors.

______ ______ ______

31. At what stage of the automated systems' life cycle should support equipment requirements determination and design take place?

ROUND 1 CONSENSUS: 68% AGREE ON DETAILED DESIGN PHASE.

**32. Technical Data: The following list of technical data factors unique to automated cartographic or photogrammetric systems was collated from Round 1 responses. Please review the list and provide the three most important technical data factors unique to automated cartographic or photogrammetric systems.

ROUND 1 RESPONSES:

1. Application software should be included in Technical data
2. Communicate with contractor when developing manuals to be used for production and maintenance
3. Configuration items index
4. COTS equipment has impact on ability to procure adequate technical data due to proprietary claims
5. Critical/Preliminary design review of O&M and Logistics Plan Equipment operations manuals
6. Hardware maintenance manuals
7. Incorporate operations manuals into technical data requirements
8. Lists of delivered hardware and software items
9. Maintenance and diagnostics documentation
10. Mathematical models
11. Monitor luminance and resolution
12. Quality assurance
13. Schematics
14. Software documentation and interface manuals
15. Stage calibration software
16. Technical data should be available on microfiche
17. Users Guides

**Please provide the numbers of the three most important technical data factors.

______ ______ ______

33. At what stage of the automated systems' life cycle should technical data requirements determination and design take place?

ROUND 1 CONSENSUS: 62% AGREE ON DETAILED DESIGN PHASE.

**34. Training: The following list of training factors unique to automated cartographic or photogrammetric systems was collated from Round 1 responses. Please review the list and provide the three most important training factors unique to automated cartographic or photogrammetric systems.

ROUND 1 RESPONSES:

1. Analytical thinking
2. Critical/preliminary design review of training plans
3. Feature identification and extraction
4. Fine motor skills training
5. Implement computer-assisted training
6. In house hardware/software training must be in depth
7. Need prerequisite training to determine level of readiness
8. Need preparatory training
9. Need segment specific training
10. Need full-up production training
11. Need follow-on training
12. Require more than two maintenance personnel be trained for any given system
13. Require contractor to train more DMA personnel initially for support activities
14. Requirement for computer skills in addition to cartographic skills
15. Self paced training courses (Auto tutorials)
16. Software maintenance requires training in photogrammetric skills
17. Training should be developed and executed by experienced cartographic and photogrammetric personnel because training often is developed from scratch

**Please provide the numbers of the three most important training factors.

_______ _______ _______

35. At what stage of the automated systems' life cycle should training requirements determination and design take place?

ROUND 1 CONSENSUS: 74% AGREE ON DETAILED DESIGN PHASE.

**36. Computer Resources Support: The following list of computer resources support factors unique to automated cartographic or photogrammetric systems was collated from Round 1 responses. Please review the list and provide the three most important computer resources support factors unique to automated cartographic or photogrammetric systems.

ROUND 1 RESPONSES:

1. Automated support and test equipment
2. COTS packages should be used in lieu of special purpose applications software
3. Diagnostic software
4. Flexibility, expandability, peak capacity, and fault isolation to LRU
5. Hardware and software should be considered as separate issues
6. Image processing
7. Need a development test facility to test software code fixes and upgrades instead of tying up production equipment
8. Operating system upgrades should be possible
9. Support for multiple brands of computers

**Please provide the numbers of the three most important computer resources support factors.

______ ______ ______

**37. At what stage of the automated systems' life cycle should computer resources support requirements determination and design take place?

ROUND 1 MEAN: 2.400

YOUR NEW RESPONSE:

1	2	3	4	5
Conceptual Phase	Advanced Development Phase	Detailed Design Phase	Production Phase	Operational Use

**38. <u>Facilities</u>: The following list of facilities factors unique to automated cartographic or photogrammetric systems was collated from Round 1 responses. Please review the list and provide the <u>three</u> most important facilities factors unique to automated cartographic or photogrammetric systems.

ROUND 1 RESPONSES:

1. Access ramps
2. Clean environment
3. Designed for human occupation not just machines
4. Electrical requirements
5. Facility preparation takes too long creating disconnect between development and facility requirements
6. Fire protection requirements
7. Humidity control
8. Lighting requirements
9. Noise reduction methods
10. Personal storage areas
11. Raised floor requirements
12. Security emanations
13. Space requirements
14. Special handling requirements
15. Static electricity reduction techniques
16. Temperature control
17. Vibration control
18. Weight requirements

**Please provide the numbers of the <u>three</u> most important facilities factors.

_______ _______ _______

**39. At what stage of the automated systems' life cycle should facilities requirements determination and design take place?

ROUND 1 MEAN: 2.400

YOUR NEW RESPONSE:

1	2	3	4	5
Conceptual Phase	Advanced Development Phase	Detailed Design Phase	Production Phase	Operational Use

**40. Packaging, Handling & Transportation: The following list of packaging, handling, & transportation factors unique to automated cartographic or photogrammetric systems was collated from Round 1 responses. Please review the list and provide the three most important packaging, handling, & transportation factors unique to automated cartographic or photogrammetric systems.

ROUND 1 RESPONSES:

1. Air ride trailers
2. Equipment size and weight
3. Mode of transportation
4. Need a special re-usable container for boards, power supplies, etc
5. Packaging materials for optical equipment
6. Personnel resources
7. Security of classified items
8. Shipment of initial equipment from contractor to customer
9. Shipment of component items from repair depot to customer
10. Storage facilities

**Please provide the numbers of the three most important packaging, handling, & transportation factors.

_______ _______ _______

41. At what stage of the automated systems' life cycle should packaging, handling & transportation requirements determination and design take place?

ROUND 1 CONSENSUS: 71% AGREE ON DETAILED DESIGN PHASE.

**42. Design Interface: The following list of design interface factors unique to automated cartographic or photogrammetric systems was collated from Round 1 responses. Please review the list and provide the three most important design interface factors unique to automated cartographic or photogrammetric systems.

ROUND 1 RESPONSES:

1. Function of overall system design
2. Mean time between failure
3. Mean time to repair
4. Mean time to restore
5. Need to incorporate this element early in the life cycle
6. Reliability/Maintainability requirements
7. Useful system life

**Please provide the numbers of the three most important design interface factors.

______ ______ ______

**43. At what stage of the automated systems' life cycle should design interface requirements determination and design take place?

ROUND 1 MEAN: 2.259

YOUR NEW RESPONSE:

1	2	3	4	5
Conceptual Phase	Advanced Development Phase	Detailed Design Phase	Production Phase	Operational Use

**44. How well does DMA apply ILS or any other logistics support planning process to automated cartographic or photogrammetric systems? Please describe any improvements which need to be made to this process. How would you suggest these improvements be accomplished?

ROUND 1 COMMENTS:

"Currently, the planning process is not done as soon as it should be- on small procurements it is an afterthought. Personnel need to be trained to think ILS during development."

"Very poorly. There is no integrated approach to logistics support planning. Individual elements are addressed separately and some of those elements are not even considered part of the ILS process. The only real elements DMA addresses as part of logistics support are maintenance supply, and support and test equipment. The other elements are not really recognized as part of the ILS process. DMA needs to place more emphasis on integrating all of the elements into a comprehensive and cohesive ILS program. More emphasis needs to placed on design interface in order to influence design for supportability in the early phases of system development. Additionally, the program managers must be made responsible for considering life cycle support, and therefore ILS, during system design and manufacture. The PM's must recognize their responsibility for integrating ILS as one of the program management elements."

"DMA needs more involvement during the Advanced Development and Detailed Design Phases in order to do a better job of supporting cartographic and photogrammetric systems.

"From my perspective, DMA does not do a good job of planning."

"Poorly- we are at least one year behind but we have contractors in place to support until we have our sea legs."

"Generally, in the past the logistics support for production systems has been adequate for production needs, which would indicate some planning process. Production departments generally supplied their own software maintenance. Reorganizations of maintenance responsibilities and increased reliance of contractor maintenance in recent years has generally lead to a decrease in the level of satisfaction on the production organizations in part."

"I saw little evidence of an ILS approach to our past systems. I do see an attempt to provide ILS to our new systems. Unfortunately, obstacles are constantly being placed in our way. Logistics is viewed as obstacle by many of the COTR type people. We need more influence earlier in the system design phases."

"Haphazardly- not enough firm financial commitment to adequately support a system. There needs to be a Logistics Directorate whose sole responsibility is maintenance without interference from the Centers or other departments with the exception of communication during times of crisis. DMA needs to get a vision of maintenance as supporting production rather than "fix it if it breaks". I would call a strong logistics organization in DMA a safeguard on the vast investment the government has made in DMA."

"DMA appears to do a great deal of planning but does not do a good job of implementing the plan. Maintenance people are often not adequately trained to support the system, spare parts are often not maintained, equipment status reports are not adequately reviewed or trend analysis performed and preventive maintenance is often not performed. I would review the completed DMA support function from top to bottom and execute a plan to raise the level of performance.

"Very poorly- Didn't apply the ILS early enough. Minimal planning in early stages. Now we are playing catch up through the RFC process."

"Fair- More responsiveness/accountable to Production Center requirements with Cost Benefit Analysis of what work/$ = most beneficial to DMA, not who has what training and is available or what crisis happens to call for $ when $ are available."

"Varies- MARK 85 and MARK 90 ILS very well done. Piecemeal buys are of great variety, some good and some non-existent."

"The one area that DMA historically has ignored is the application of ILS during the conceptual phase of development rather than at the, too typically, unfortunately, operational phase. MARK 85 and MARK 90 systems are examples of how DMA is changing with respect to ILS. DMA needs to follow the formal processes of the life cycles of systems in a more rigorous manner for all systems, as is being done for MARK 90."

"I believe that DMA does a reasonably good job of dealing with systems development and operation. However, we do not approach it in the same way as espoused by the USAF. In recent times we have had agency directors who have tried to dictate organizational and process changes to get more in line and I have yet to see the benefits- perhaps somewhere in the future they will pay off."

"DMA hasn't done this very well in the past. As a result, DMA Director is creating a Directorate for Acquisition, Installation, and Logistics. ADD/Logistics includes four divisions: Logistics Plans, Distribution, Maintenance, and Supply. This will eliminate many of DMA's fragmented logistics activities and result in a proactive consolidated logistics organization that is more capable of developing, planning, and implementing true ILS."

"We take too long to start the process, as a result ILS doesn't do what it is intended to do (decisions have already been made)."

"We have done reasonably well with the Digital Production System and subsequent large procurements."

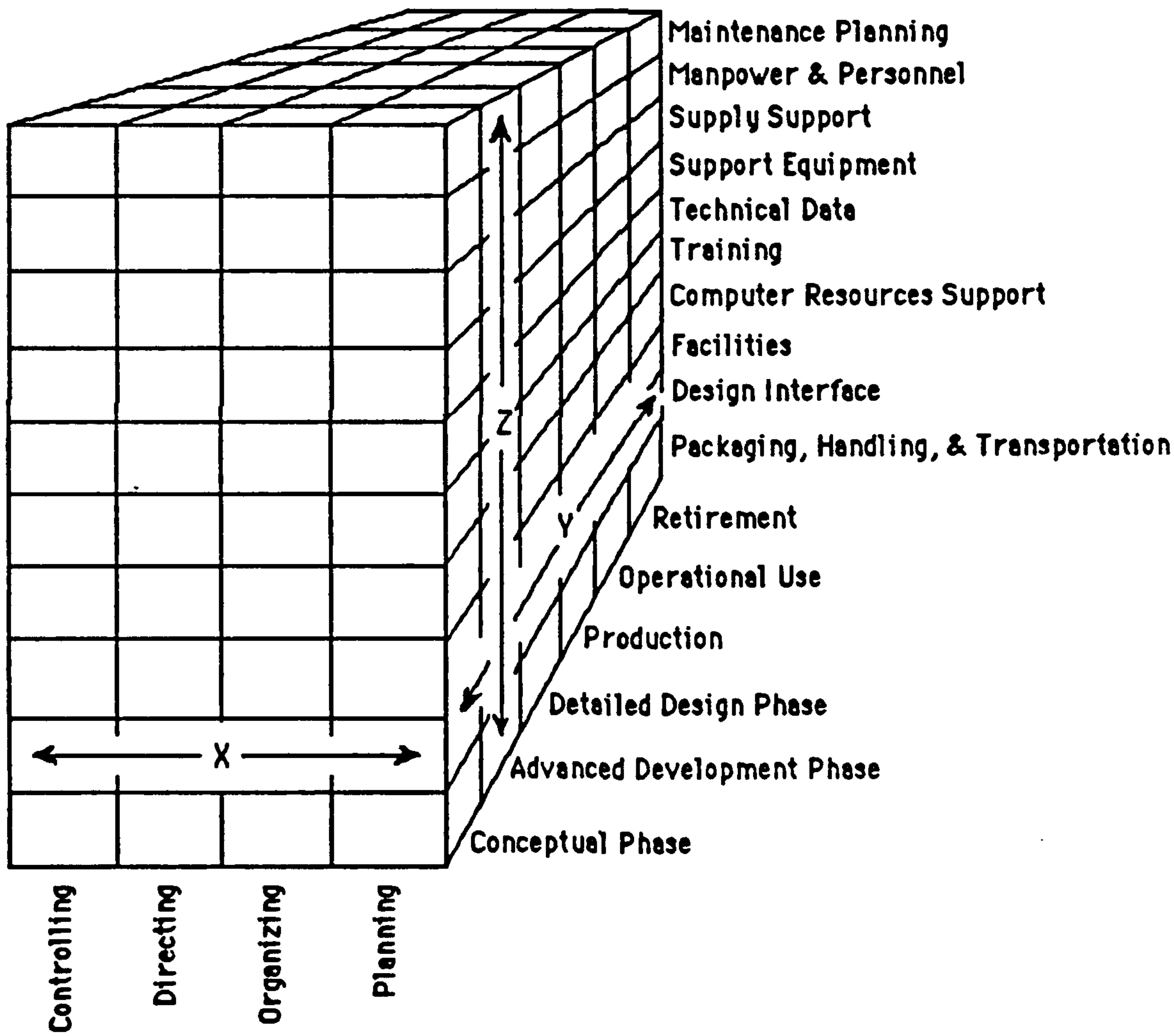
"ILS is a major player. Systems could not be delivered or maintained, facilities would not be adequate, and personnel wouldn't be trained without ILS. ILS has always been a fuzzy area that I always relied on a logistics person to work. I provided the logistics office the technical specs of what was needed by when, and they always came through."

"Not very well- The MARK 90 development is trying to establish system level requirements documents for ILS which will help. Problem is that content requirements of the documents are overlooked. Biggest improvement: Start planning earlier."

YOUR NEW COMMENTS:

LOGISTICS SYSTEMS MANAGEMENT MATRIX (LSMM)

Research has suggested that a model such as the Logistics Systems Management Matrix (LSMM) below forms the basis for proper implementation of any given system. The LSMM is a three-dimensional model with principles of management on the "X" axis, design or life cycle processes on the "Y" axis, and the ILS elements on the "Z" axis. Please use Attachment #1 as a reference in answering questions 11 through 22.



The Logistics Systems Management Matrix

ATTACHMENT #1

DESIGN OR LIFE CYCLE PHASES

1. Conceptual Phase: This phase is where the product or service system is defined, acquisition requirements are determined, production and operational support requirements are identified and logistics support planning is established.

2. Advanced Development Phase: This phase identifies and defines the product configuration. It deals with product objectives, performance limits, areas of risk, alterations and acquisition methodologies. During this phase, logistics support analysis is conducted to verify design concepts, followed by the initiation of the logistics support plan.

3. Detailed Design Phase: This phase includes the design and test of the product. It consists of design effects on reliability, maintainability, sustainability, human factors issues and logistics support. Engineering modes and prototypes are developed. At this time, the formal logistic support plan is completed.

4. Production Phase: This phase consists of producing the product and its support, such as test and support equipment, spare parts, training personnel, software, physical distribution and transportation, and warehousing.

5. Operational Use: This phase covers all of the activities associated with consumer use and logistics support, to include maintenance and sustainability.

6. Retirement: This phase consists of all of the actions necessary to phase out and dispose of the system, to include waste management, recycling or other responsive actions. Fast obsolescence systems, such as automated cartographic or photogrammetric systems, require retirement planning early in the life cycle to ensure proper phase-out of old systems and implementation of new systems.

ATTACHMENT #2

ILS ELEMENTS

The following ILS definitions come from the Integrated Logistics Support Guide published by the Defense Systems Management College. Each definition is a short synopsis for that particular ILS element. Please use the ILS definitions provided in Attachment #2 as a reference in answering Questions 23 through 42.

1. Maintenance Planning: The process conducted by the Government and contractor to explore alternatives and to develop the maintenance concepts and maintenance requirements for the life of the material system. Maintenance planning is the lead analytical activity and provides input to the development of all of the remaining logistics support elements.

2. Manpower and Personnel: The element which encompasses the identification and acquisition of military and civilian personnel with the skills and grades required to operate and support a material system over its lifetime at peacetime and wartime rates.

3. Supply Support: The element which encompasses all actions required to identify and obtain the spares and repair parts needed to support peacetime and wartime readiness objectives.

4. Support Equipment: The element which encompasses all equipment required to support operation and maintenance of the material system. This includes ground handling equipment, tools, metrology and calibration equipment, test equipment, and logistic support for the support equipment.

5. Technical Data: The element which encompasses all recorded information of a scientific or technical nature related to a program. Technical data are written instructions such as drawings; operating and maintenance manuals; specifications, inspection, test and calibration procedures; and computer programs which guide personnel performing operations and support tasks.

6. Training: The element which encompasses all of the processes, procedures, techniques, training devices and equipment used to train personnel to operate and support a material system. Examples include individual and group training; new equipment training; initial, formal and on-the-job training; and logistic support planning for training equipment.

ATTACHMENT #3

7. Computer Resources Support: The element is defined as all computer equipment, software, associated documentation, contractual services, personnel, and supplies needed to operate and support an embedded computer system.

8. Facilities: The element which encompasses those real property assets required to support the material system, and the studies which define types of facilities or facility improvements, locations, space needs, etc.

9. Packaging, Handling & Transportation: The element which includes the characteristics, action and requirements necessary to ensure the capability to transport, preserve, package, and handle all equipment and support items.

10. Design Interface: The element which is an interactive relationship of logistics-related design parameters, such as R&M, to readiness and logistic support resource requirements.

ATTACHMENT #3

Appendix H: Round Two Delphi Survey Comments

Basic Characteristics of the LSMM Model.

Basic Structure.

How would you change the LSMM?

"Disagree with adding resources = $$. Resources are a limiting factor to the individual categories as well as to the model as a whole. "Transition is not a separate logistics step; one could put a "transition" step between every life cycle phase. Test equipment should not be a separate element because it is a type of "support equipment". DMA should use DOD terminology rather than its own. The LSMM is a <u>logistics systems model</u>. Models can be as simple or as complex as we want. Recommend the following changes: (1) under "controlling" add "including budgeting"; (2) on the "Z" axis add a separate software category; (3) realign "Z" axis (bottom to top): maintenance planning, design interface, technical data, software, computer resources support, support equipment, supply support, facilities, packaging, handling, storage, & transportation, manpower and personnel, and training."

"A number of comments were made on the life cycle phases. Generally speaking, I think we should be consistent with the phases designated in DODD 5000.1, which is being revised. Under the revised Directive DMA will no longer be able to make claims of exemption. The DPS program has been under scrutiny as a result of the claim of exemption, as noted by the DOD IG. Although I'm not sure, there may be provisions for product improvement in the new DODD 5000.1."

"Add security considerations to the "Z" axis."

"I would agree that transition and $$ resources should be added to the model. The glass is half full or half empty with respect to maintenance planning - it should/could be included in overall <u>planning</u>."

"Add delivery, installation, test and acceptance, and operational refinement to "Y" axis."

"There is nothing wrong with the model. It is only how the model is implemented that is the problem."

"If your intention is to use the generic LSMM for DMA systems, then the majority of the round one comments need to be accommodated."

"Add budgeting to the "X" axis and delete maintenance planning and computer resources support and replace with hardware maintenance and software support. The definition of software support should include system and applications software maintenance, COTS upgrades, and the maintenance of documentation. In general, the model does not reflect the situation that we have typically with DMA automated cartographic or photogrammetric systems which is one of continual change and evolution over the lifetime of a production system. Typically, the hardware changes slowly, but there is usually a fairly steady and rapid change in software, often punctuated by major software changes in capability and/or replacement/upgrade of computer components. Such system components as stereoplotters or scanners may change little over a 20 year period."

"Change "Advanced Development Phase" to "Development Phase". Add software and hardware maintenance as separate items to the "Z" axis."

Design or Life Cycle Processes.

How would you change the design or life cycle phases proposed in the LSMM?

"Waiting until the later phases before considering logistics support planning is an invitation to inefficient and ineffectiveness at best and disaster at worst. Past records within DOD clearly demonstrate that life cycle logistics support costs often exceed initial purchase cost by 3 to 5 times. Accordingly, ILS must be considered early and continue to be a strong player throughout the process."

"Production and operational phases should be combined. Add production improvement phase. Add preliminary design phase and transition to production phase."

"Common DMA terms for life cycle phases are as follows:

Conceptual	=	Design Concept
Advanced Development	=	Preliminary Design
Detailed Design	=	Critical Design
Production	=	Build
(No Counterpart)	=	Transition
Operational Use	=	Production Operations
Retirement	=	Excessing

Because DMA is a production organization, the use of the word production when associated with cartographic or photogrammetric systems is usually synonymous with "operational use" in the LSMM model. This causes miscommunication between ILS personnel and DMA end users. "Retirement" - A comment- DMA has systems that have been in production operations for over 20 years. They cannot be considered as fast obsolescence systems."

"I would agree with the incorporation of a transition phase and the breakout of the operational phase."

Integrated Logistics Support (ILS) Elements.

Which of the ILS elements are not applicable to automated cartographic or photogrammetric systems? Why are they not applicable?

"None - The least important call is tough even packaging, handling, storage, & transportation is important with a planning factor of 1000 failed LRU's a month, most of which must be shipped out for depot maintenance."

"Some of the respondents don't seem to comprehend that ILS is a process, not just an organization. The process and the ILS manager implementing the process integrates the separate logistics elements into a cohesive and comprehensive logistics support program. The ILS manager or the ILS office does not necessarily have direct authority and responsibility for each and every one of the separate logistics elements. It is important for each of those elements to recognize they play a part in the ILS process and the impact their decisions may have on the other logistics support elements."

"Perhaps the LSMM should be tailored to DMA elements. Also, ILS concepts are not uniformly understood throughout DMA."

"There should be a distinction between operations manpower and maintenance manpower. The determination of the numbers of operations manpower is part of the production programming process and is driven by the required production rates. Operations manpower requirements determination is not part of the ILS process."

"Design interface still seems the least well defined."

"All parts of ILS are important, but unless we plan to move systems, packaging, handling, storage, & transportation is probably the least important. I think some participants missed the point concerning manpower and personnel - in ILS this usually refers to the people maintaining the system, not the operators. Remember, this is a logistics model. There is another whole world that analyzes what the system does, how does it work, and who operates it."

How would you change any of the ILS elements proposed in the LSMM?

"Assigning ILS tasks to a contractor is possible, but that doesn't eliminate those requirements or abrogate our responsibility for ensuring ILS requirements are met."

"ADP security needs to be added."

"Since some respondents didn't seem to understand design interface, additional definition would probably be helpful. Computer Resources Support is also unclear. Maybe it should be reworded to something more along the line of the "Post Deployment Software Support" chapter in DMSC's Mission Critical Computer Resources Guide. Software support should not be lumped under maintenance planning."

"There should be a distinction between the production use of a system and system support. Training and determination of staffing levels for operational use of the system is a mission related process."

"If the LSMM is a model to be used throughout all of the phases of a system, then the model should be revised. The ILS elements are oriented toward the planning aspects of logistics support rather than execution. Thus, it is hard to identify in the LSMM an element for directing hardware maintenance activities, as an example."

"Security support should be added."

> Are there any elements in the logistics support planning of automated cartographic or photogrammetric systems not addressed by the LSMM model? Please specify and describe what these elements are.

"We need to concern ourselves more with Total Quality Management (TQM) and Configuration Management (CM)."

"What is missing is the fact that ILS puts a tremendous overhead on the whole process. We must find a way to make ILS work with minimal impact."

"All of these things can be covered under the existing ILS process. The process is not equipment type specific and in fact, command and control systems frequently encounter the same constant upgrade of software capabilities There is nothing in the process that can't cover all the comments. You simply tailor the program accordingly."

"Add security requirements and considerations."

"The model represents a basic conception through death linear process. Most of our systems go through continual cycles of growth, decay, regeneration, and reincarnation before they finally die."

"Security considerations are important and need to be included."

Logistics Support Planning Applications within DMA.

> How well does DMA apply ILS or any other logistics support planning process to automated cartographic or photogrammetric systems? Please describe any improvements which need to be made to this process. How would you suggest these improvements be accomplished?

"DMA is recognizing the importance of ILS. The creation of the new Directorate of Acquisition, Installation, and Logistics should help institutionalize the process. The ILS awareness expressed by our senior managers needs to be nurtured. Above all, ILS must be seen as a process that will enhance the effectiveness and efficiency of our production systems through increased reliability, maintainability, and availability."

"There is no Integrated Logistics Support process in place for MARK 85 and MARK 90! It is piecemeal. Emphasis must be placed on design for supportability, so the support process is not merely reacting to what has already been locked in during design. What support we have managed to provide has been "in spite of" rather than "because of" DMA's degree of attention toward logistics support."

"DMA logisticians must demonstrate what they can contribute to the overall function of DMA."

"It is extremely difficult to rank most or least important on categories where all the constituents are essential to the success of production systems development, delivery, test, and production use."

"In general, life cycle costs are not addressed well in DMA. The objective of system developers is often to minimize development cost at the expense of total system life cycle costs. Because of the nature of our mission and the evolution of our systems over what is typically a very long life cycle, flexibility, adaptability, and long term maintainability should be given more consideration in the design process than have frequently been the case."

"I need to reiterate and augment a portion of a previous comment: Program Managers must be made responsible for the life cycle support, and therefore ILS, during the system design and development. I would even go further and state that Program Managers should be responsible for the total support during the life cycle of a system."

"Interesting perspectives... Many think "earlier" when in reality all you get is less firmness. Best time to finalize an ILS plan is when you are building something."

"Logistics is not being accomplished. Some maintenance is done, some supply is done, a portion of all logistics elements is being done. No one is looking at the logistics umbrella as a comprehensive integrated system. The failure to do this will add a minimum of 10% to support costs."

"We simply haven't done a good job here - we constantly play catch up."

"ILS has not been formalized within DMA. As DOD becomes more demanding of ILS, the Defense Agencies will and are starting to give ILS more serious considerations."

Appendix I: Delphi Survey Respondents

Defense Mapping Agency Headquarters (DMAHQ)

Mr. Penman R. Gilliam
Mr. Mordecai Z. Labovitz
Mr. George A. Pelletiere
Mr. James Sippel
Ms. Janice Wollaber

Defense Mapping Agency Systems Center (DMASC)

Mr. Merle J. Biggin
Mr. John W. Bukoski
Mr. Frederick J. Doyle, Jr.
Mr. Gerald M. Elphingstone
Mr. Clyde F. Housel
Lt Col Jay L. Larson, USAF
Mr. Robert F. Seebald
Mr. Charles K. Shand, Jr.
Mr. Herbert F. Smith
Mr. Morris S. Solomon
Ms. Linda J. Sullivan
Mr. Michael B. Wagner
Mr. John Webster

Defense Mapping Agency Telecommunications Services Center (DMATSC)

Mr. Bill Robinson

Defense Mapping Agency Reston Center (DMARC)

Mr. Darryl Crumpton
Mr. Russell Gustin
Col Peter G. O'Neill, USA
Mr. Paul L. Peeler, Jr.

Defense Mapping Agency Hydrographic/Topographic Center (DMAHTC)

Capt John E. Chubb, USN
Mr. Thomas K. Coghlan
Ms. Maureen P. Currie
Mr. David S. Scopp
Mr. Lon M. Smith

Defense Mapping Agency Aerospace Center (DMAAC)

Mr. Leslie R. Kemp
Mr. James R. Skidmore
Ms. Kathleen M. Smith

Appendix J: Unique Factors of ILS Elements

Maintenance Planning. Table 39 lists the maintenance planning factors unique to automated cartographic or photogrammetric systems provided by the DMA experts. The list was collated from round one responses.

Table 39

Maintenance Planning Factors Unique to Automated Cartographic or Photogrammetric Systems -- Round One Delphi Survey

1. Adaptive hardware/software maintenance
2. Corrective hardware/software maintenance
3. Critical/preliminary design review of maintenance documents
4. Determine whether maintenance support will be in-house or contract
5. Failure rates hard to predict due to changing production priorities for systems
6. Lack of application or standard techniques
7. Logisticians must be involved in system development to adequately plan for maintenance support
8. Maintenance of electrical boards
9. Maintenance planning should be a continuous process throughout the life cycle of these systems
10. Maintenance security issues associated with volatile/non-volatile memory
11. Must conform to existing logistics maintenance planning guidelines
12. No unique factors-same as any workstation automated system
13. On call maintenance procedures should be established
14. Plan for possible default by contractors after turnover
15. Preventive hardware/software maintenance
16. Preliminary design review of maintenance documents
17. Rapid obsolescence
18. Sensitive security requirements
19. Special skills to maintain unique equipment (Automatic correlation equipment, optics)

Manpower and Personnel. Table 40 lists the manpower/personnel factors unique to automated cartographic or photogrammetric systems provided by the DMA experts. The list was collated from round one responses.

Table 40

Manpower/Personnel Factors Unique
to
Automated Cartographic or Photogrammetric Systems
-- Round One Delphi Survey

1. Ability to retain competent personnel
2. Additional personnel in communication, optics, and unique electronics
3. Cadre of personnel should remain with the system from development through operational use
4. Education and technical background of users
5. Fatigue and boredom
6. Lead time for security clearances
7. Limited skilled personnel to maintain hardware and software
8. Operational planning the key driver of manpower requirements
9. Physical/technical skills required for photogrammetric work
10. Professional cartographic work force
11. Proper planning for staffing the automated systems
12. Require that more than two hardware maintenance personnel have knowledge of any one system
13. Stereo acuity
14. Systems need to be designed and maintained to meet requirements of production manpower and personnel

Supply Support. Table 41 lists the supply support factors unique to automated cartographic or photogrammetric systems provided by the DMA experts. The list was collated from round one responses.

Table 41

Supply Support Factors Unique
to
Automated Cartographic or Photogrammetric Systems
-- Round One Delphi Survey

1. Adequate shelf stock of required parts
2. Commercial Off-the-Shelf (COTS) equipment has impact on the provisioning process, proprietary data rights, and basic supply support concept
3. Dependent on local purchase due to unique spares not being stocked in DOD supply system
4. Hardware life cycle is over before systems are in full production
5. Initial spare start-up quantities
6. Large computer maintenance contracts
7. Optical components
8. Staging of spares
9. Steady state life cycle spare requirements
10. Tapes, removable drives, plotter pens, plotter paper
11. Unique systems need unique spares, requiring long lead time

Support Equipment. Table 42 lists the support equipment factors unique to automated cartographic or photogrammetric systems provided by the DMA experts. The list was collated from round one responses.

Table 42

Support Equipment Factors Unique
to
Automated Cartographic or Photogrammetric Systems
-- Round One Delphi Survey

1. Calibration of support and test equipment
2. Calibration of photogrammetric equipment is critical
3. Design for easily replaced logical units, which are easily repaired
4. Electronic circuit board testing and analysis equipment
5. Identification of support and test equipment
6. Infreometers
7. Optical alignment equipment
8. Resolution targets
9. Screen luminance measuring equipment
10. Signal generators
11. Unique IBM gear

Technical Data. Table 43 lists the technical data factors unique to automated cartographic or photogrammetric systems provided by the DMA experts. The list was collated from round one responses.

Table 43

Technical Data Factors Unique
to
Automated Cartographic or Photogrammetric Systems
-- Round One Delphi Survey

1. Application software should be included in Technical data
2. Communicate with contractor when developing manuals to be used for production and maintenance
3. Configuration items index
4. COTS equipment has impact on ability to procure adequate technical data due to proprietary claims
5. Critical/Preliminary design review of O&M and Logistics Plan Equipment operations manuals
6. Hardware maintenance manuals
7. Incorporate operations manuals into technical data requirements
8. Lists of delivered hardware and software items
9. Maintenance and diagnostics documentation
10. Mathematical models
11. Monitor luminance and resolution
12. Quality assurance
13. Schematics
14. Software documentation and interface manuals
15. Stage calibration software
16. Technical data should be available on microfiche
17. Users Guides

Training. Table 44 lists the training factors unique to automated cartographic or photogrammetric systems provided by the DMA experts. The list was collated from round one responses.

Table 44

Training Factors Unique
to
Automated Cartographic or Photogrammetric Systems
-- Round One Delphi Survey

1. Analytical thinking
2. Critical/preliminary design review of training plans
3. Feature identification and extraction
4. Fine motor skills training
5. Implement computer-assisted training
6. In house hardware/software training must be in depth
7. Need prerequisite training to determine level of readiness
8. Need preparatory training
9. Need segment specific training
10. Need full-up production training
11. Need follow-on training
12. Require more than two maintenance personnel be trained for any given system
13. Require contractor to train more DMA personnel initially for support activities
14. Requirement for computer skills in addition to cartographic skills
15. Self paced training courses (Auto tutorials)
16. Software maintenance requires training in photogrammetric skills
17. Training should be developed and executed by experienced cartographic and photogrammetric personnel because training often is developed from scratch

Computer Resources Support. Table 45 lists the computer resources support factors unique to automated cartographic or photogrammetric systems provided by the DMA experts. The list was collated from round one responses.

Table 45

Computer Resources Support Factors Unique to Automated Cartographic or Photogrammetric Systems -- Round One Delphi Survey

1. Automated support and test equipment
2. COTS packages should be used in lieu of special purpose applications software
3. Diagnostic software
4. Flexibility, expandability, peak capacity, and fault isolation to LRU
5. Hardware and software should be considered as separate issues
6. Image processing
7. Need a development test facility to test software code fixes and upgrades instead of tying up production equipment
8. Operating system upgrades should be possible
9. Support for multiple brands of computers

Facilities. Table 46 lists the facilities factors unique to automated cartographic or photogrammetric systems provided by the DMA experts. The list was collated from round one responses.

Table 46

Facilities Factors Unique
to
Automated Cartographic or Photogrammetric Systems
-- Round One Delphi Survey

1. Access ramps
2. Clean environment
3. Designed for human occupation not just machines
4. Electrical requirements
5. Facility preparation takes too long creating disconnect between development and facility requirements
6. Fire protection requirements
7. Humidity control
8. Lighting requirements
9. Noise reduction methods
10. Personal storage areas
11. Raised floor requirements
12. Security emanations
13. Space requirements
14. Special handling requirements
15. Static electricity reduction techniques
16. Temperature control
17. Vibration control
18. Weight requirements

Packaging, Handling, Storage, & Transportation. Table 47 lists the packaging, handling, storage, & transportation factors unique to automated cartographic or photogrammetric systems provided by the DMA experts. The list was collated from round one responses.

Table 47

Packaging, Handling, Storage, & Transportation Factors Unique to Automated Cartographic or Photogrammetric Systems -- Round One Delphi Survey

1. Air ride trailers
2. Equipment size and weight
3. Mode of transportation
4. Need a special re-usable container for boards, power supplies, etc
5. Packaging materials for optical equipment
6. Personnel resources
7. Security of classified items
8. Shipment of initial equipment from contractor to customer
9. Shipment of component items from repair depot to customer
10. Storage facilities

Design Interface. Table 48 lists the design interface factors unique to automated cartographic or photogrammetric systems provided by the DMA experts. The list was collated from round one responses.

Table 48

Design Interface Factors Unique
to
Automated Cartographic or Photogrammetric Systems
-- Round One Delphi Survey

1. Function of overall system design
2. Mean time between failure
3. Mean time to repair
4. Mean time to restore
5. Need to incorporate this element early in the life cycle
6. Reliability/Maintainability requirements
7. Useful system life

Appendix K: Ranked Unique Factors of ILS Elements

Maintenance Planning. Table 49 lists the ranking and frequency count of maintenance planning factors unique to automated cartographic or photogrammetric systems as provided by the DMA experts in round two.

Table 49

Maintenance Planning Factors Unique to Automated Cartographic or Photogrammetric Systems -- Round Two Delphi Survey

		Frequency
1.	Determine whether maintenance support will be in-house or contract	14
2.	Corrective hardware/software maintenance	11
3.	Maintenance planning should be a continuous process throughout the life cycle systems	10
4.	Logisticians involved in system development to plan for maintenance support	8
5.	Adàptive hardware/software maintenance	7
6.	Critical/preliminary design review of maintenance documents	6
7.	Special skills to maintain unique equipment (Automatic correlation equipment, optics)	4
8.	Preventive hardware/software maintenance	4
9.	Lack of application or standard techniques	3
10.	Maintenance security issues associated with volatile/non-volatile memory	2
11.	Failure rates hard to predict due to changing production priorities for systems	1
12.	Must conform to existing logistics maintenance planning guidelines	1
13.	No unique factors-same as any workstation automated system	1
14.	On call maintenance procedures established	1
15.	Plan for possible default by contractors	1
16.	Sensitive security requirements	1
17.	Maintenance of electrical boards	0
18.	Preliminary design review of maintenance documents	0
19.	Rapid obsolescence	0

Manpower and Personnel. Table 50 lists the ranking and frequency count of manpower/personnel factors unique to automated cartographic or photogrammetric systems as provided by the DMA experts in round two.

Table 50

Manpower/Personnel Factors Unique
to
Automated Cartographic or Photogrammetric Systems
-- Round Two Delphi Survey

		Frequency
1.	Ability to retain competent personnel	20
2.	Limited skilled personnel to maintain hardware and software	10
3.	Systems need to be designed and maintained to meet requirements of production manpower and personnel	9
4.	Proper planning for staffing the automated systems	6
5.	Education and technical background of users	5
6.	Operational planning the key driver of manpower requirements	5
7.	Additional personnel in communication, optics, and unique electronics	4
8.	Cadre of personnel to remain with the system from development through operational use	4
9.	Lead time for security clearances	3
10.	Professional cartographic work force	3
11.	Fatigue and boredom	2
12.	Physical/technical skills required for photogrammetric work	2
13.	Require that more than two hardware maintenance personnel have knowledge of any one system	1
14.	Stereo acuity	1

Supply Support. Table 51 lists the ranking and frequency count of supply support factors unique to automated cartographic or photogrammetric systems as provided by the DMA experts in round two.

Table 51

Supply Support Factors Unique to Automated Cartographic or Photogrammetric Systems -- Round Two Delphi Survey

		Frequency
1.	Adequate shelf stock of required parts	18
2.	Unique systems need unique spares, requiring long lead time	13
3.	Commercial Off-the-Shelf (COTS) equipment has impact on the provisioning process, proprietary data rights, and basic supply support concept	10
4.	Initial spare start-up quantities	8
5.	Hardware life cycle is over before systems are in full production	7
6.	Dependent on local purchase due to unique spares not being stocked in DOD supply system	5
7.	Staging of spares	5
8.	Large computer maintenance contracts	4
9.	Steady state life cycle spare requirements	3
10.	Optical components	1
11.	Tapes, removable drives, plotter pens, plotter paper	1

<u>Support Equipment</u>. Table 52 lists the ranking and frequency count of support equipment factors unique to automated cartographic or photogrammetric systems as provided by the DMA experts in round two.

Table 52

Support Equipment Factors Unique
to
Automated Cartographic or Photogrammetric Systems
-- Round Two Delphi Survey

	Frequency
1. Calibration of support and test equipment	16
2. Design for easily replaced logical units, which are easily repaired	15
3. Calibration of photogrammetric equipment is critical	11
4. Identification of support and test equipment	10
5. Electronic circuit board testing and analysis equipment	9
6. Optical alignment equipment	2
7. Screen luminance measuring equipment	1
8. Infreometers	0
9. Resolution targets	0
10. Signal generators	0
11. Unique IBM gear	0

Technical Data. Table 53 lists the ranking and frequency count of technical data factors unique to automated cartographic or photogrammetric systems as provided by the DMA experts in round two.

Table 53

Technical Data Factors Unique to Automated Cartographic or Photogrammetric Systems -- Round Two Delphi Survey

		Frequency
1.	Maintenance and diagnostics documentation	10
2.	Software documentation and interface manuals	10
3.	Communicate with contractor when developing manuals used for production and maintenance	9
4.	Critical/Preliminary design review of O&M and Logistics Plan Equipment operations manuals	8
5.	Lists of delivered hardware and software items	5
6.	COTS equipment has impact on ability to procure adequate technical data due to proprietary claims	5
7.	Application software should be included in Technical data	4
8.	Hardware maintenance manuals	4
9.	Incorporate operations manuals into technical data requirements	4
10.	Mathematical models	3
11.	Schematics	3
12.	Users Guides	2
13.	Stage calibration software	1
14.	Configuration items index	0
15.	Monitor luminance and resolution	0
16.	Quality assurance	0
17.	Technical data should be available on microfiche	0

Training. Table 54 lists the ranking and frequency count of training factors unique to automated cartographic or photogrammetric systems as provided by the DMA experts in round two.

Table 54

Training Factors Unique
to
Automated Cartographic or Photogrammetric Systems
-- Round Two Delphi Survey

		Frequency
1.	Critical/preliminary design review of training plans	8
2.	In house hardware/software training must be in depth	8
3.	Need preparatory training	7
4.	Need segment specific training	7
5.	Need full-up production training	6
6.	Require more than two maintenance personnel be trained for any given system	6
7.	Self paced training courses (Auto tutorials)	6
8.	Need prerequisite training to determine level of readiness	4
9.	Requirement for computer skills in addition to cartographic skills	4
10.	Training should be developed and executed by experienced cartographic and photogrammetric personnel because training often is developed from scratch	4
11.	Analytical thinking	3
12.	Implement computer-assisted training	3
13.	Software maintenance requires training in photogrammetric skills	3
14.	Need follow-on training	2
15.	Require contractor to train more DMA personnel initially for support activities	2
16.	Feature identification and extraction	1
17.	Fine motor skills training	1

Computer Resources Support. Table 55 lists the ranking and frequency count of computer resources support factors unique to automated cartographic or photogrammetric systems as provided by the DMA experts in round two.

Table 55

Computer Resources Support Factors Unique to Automated Cartographic or Photogrammetric Systems -- Round Two Delphi Survey

	Frequency
1. Diagnostic software	15
2. Flexibility, expandability, peak capacity, and fault isolation to LRU	12
3. Need a development test facility to test software code fixes and upgrades instead of tying up production equipment	12
4. Automated support and test equipment	9
5. Operating system upgrades should be possible	9
6. COTS packages should be used in lieu of special purpose applications software	6
7. Image processing	5
8. Hardware and software should be considered as separate issues	4
9. Support for multiple brands of computers	3

Facilities. Table 56 lists the ranking and frequency count of facilities factors unique to automated cartographic or photogrammetric systems as provided by the DMA experts in round two.

Table 56

Facilities Factors Unique
to
Automated Cartographic or Photogrammetric Systems
-- Round Two Delphi Survey

		Frequency
1.	Designed for human occupation not just machines	18
2.	Clean environment	12
3.	Space requirements	7
4.	Security emanations	6
5.	Temperature control	5
6.	Electrical requirements	5
7.	Humidity control	5
8.	Fire protection requirements	4
9.	Lighting requirements	3
10.	Facility preparation takes too long creating disconnect between development and facility requirements	2
11.	Personal storage areas	2
12.	Vibration control	2
13.	Access ramps	1
14.	Noise reduction methods	1
15.	Special handling requirements	1
16.	Raised floor requirements	0
17.	Static electricity reduction techniques	0
18.	Weight requirements	0

Packaging, Handling, Storage, & Transportation. Table 57 lists the ranking and frequency count of packaging, handling, storage, & transportation factors unique to automated cartographic or photogrammetric systems as provided by the DMA experts in round two.

Table 57

Packaging, Handling, Storage, & Transportation Factors Unique to Automated Cartographic or Photogrammetric Systems -- Round Two Delphi Survey

	Frequency
1. Security of classified items	13
2. Equipment size and weight	10
3. Shipment of component items from repair depot to customer	8
4. Storage facilities	8
5. Packaging materials for optical equipment	7
6. Mode of transportation	6
7. Need a special re-usable container for boards, power supplies, etc	6
8. Shipment of initial equipment from contractor to customer	5
9. Personnel resources	3
10. Air ride trailers	2

__Design Interface__. Table 58 lists the ranking and frequency count of design interface factors unique to automated cartographic or photogrammetric systems as provided by the DMA experts in round two.

Table 58

Design Interface Factors Unique to Automated Cartographic or Photogrammetric Systems -- Round Two Delphi Survey

	Frequency
1. Function of overall system design	19
2. Reliability/Maintainability requirements	17
3. Need to incorporate this element early in the life cycle	11
4. Useful system life	10
5. Mean time between failure	8
6. Mean time to repair	5
7. Mean time to restore	3

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13. ABSTRACT *(Maximum 200 words)*
This study provides an exploratory view of logistical support procedures for Defense Mapping Agency (DMA) automated cartographic or photogrammetric systems. Its purpose was to develop an Integrated Logistics Support (ILS) model tailored to the requirements of DMA automated cartographic or photogrammetric systems. The literature review identified Ostrofsky's Logistics Systems Management Matrix (LSMM) as an acceptable conceptual foundation for the development of a descriptive logistics support model for DMA. A Delphi survey provided the means for constructing a descriptive model by polling 31 DMA administrative, research and development, support and maintenance, and production experts. Research findings supported the need for DMA to implement both a structured, ILS approach to automated cartographic or photogrammetric systems planning and an integrated organizational structure permitting the execution of an ILS plan. The study also certified the need to determine and design logistics support requirements early in the system life cycle with attention given to those support factors identified as unique to DMA. Special considerations should be given to maintenance planning as the experts determined this ILS element as absolutely critical to the effective logistics support of automated cartographic or photogrammetric systems. 25

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